FINAL REPORT

WATER CONSERVATION STUDY

BADGER ARMY AMMUNITION PLANT
BARABOO, WISCONSIN

Prepared for

U.S. ARMY ENGINEER DISTRICT, OMAHA
CEMRO-ED-MC
215 NORTH 17TH STREET
OMAHA, NE 68012

Under

U.S. ARMY ENGINEER DISTRICT, MOBILE
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CONTRACT NO. DACA01-94-D-0033
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EMC ENGINEERS, INC.

DENVER, COLORADO
ATLANTA, GEORGIA

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Prepared for

Department of the Army
U.S. Army Engineer District
Omaha, Nebraska

Under

U.S. Army District, Mobile
IDIQ Contract for A-E Services
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DTIC QUALITY INSPECTED 2

By

EMC Engineers, Inc.
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This report has been prepared at the request of the client, and the observations, conclusions, and recommendations contained herein constitute the opinions of EMC Engineers, Inc. In preparing this report, EMC has relied on some information supplied by the client, the client's employees, and others which we gratefully acknowledge. Because no warranties were given with this source of information, EMC Engineers, Inc. cannot make certification or give assurances except as explicitly defined in this report.

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LIST OF ABBREVIATIONS

A	-	ampere
BAAP	-	Badger Army Ammunition Plant
COE	-	Corps of Engineers
CY	-	cubic yards
ECIP	-	Energy Conservation Investment Program
ECO	-	Energy Conservation Opportunity
EMC	-	E M C Engineers, Inc.
F	-	Fahrenheit
ft	-	foot, feet
ft^2	-	square feet
gal	-	gallons
gpd	-	gallons per day
gpm	-	gallons per minute
hp	-	horsepower
hr	-	hour
in	-	inch
IRM	-	Pump and Treat Facility
kgal	-	kilo-gallon, one thousand gallons
kW	-	kilowatt, one thousand watts
kWh	-	kilowatt-hours, one thousand watt-hours
LCCA	-	Life Cycle Cost Analysis
LF	-	linear foot (feet)
MES	-	M.E. Simpson Co., Inc.
mi	-	mile(s)
O&M	-	operation and maintenance manual
rpm	-	revolutions per minute
SIOH	-	supervision, inspection and overhead
SIR	-	Savings-to-Investment Ratio
SOW	-	scope of work
SPB	-	simple payback

temp	-	temperature
UPW	-	Uniform Present Worth factor
yr	-	year(s)

EXECUTIVE SUMMARY

INTRODUCTION

Authorization for Study

This study was conducted and this report prepared under Contract No. DACA01-94-D-0033, Delivery Order No. 0004. The contract was issued by the Department of the Army, Mobile District, Corps of Engineers, to E M C Engineers, Inc. (EMC).

Purpose of Study

The purpose of this water conservation study is to identify projects which will result in energy maintenance and cost savings in the process water distribution system at Badger Army Ammunition Plant (BAAP) in Baraboo, Wisconsin.

Method of Analysis

Specific work required includes:

1. Perform a limited site survey of the process water system to collect data required to evaluate specific energy conservation opportunities (ECOs).

2. Conduct a thorough survey of the process water system using state-of-the-art underground leak detection equipment on all piping 6 inches and larger.

3. Develop a process water map which shows the location and estimated quantity of leaks identified during the leak detection survey.

4. Evaluate specific ECOs to determine energy savings potential and economic feasibility.

5. Provide project documentation for recommended ECOs.

6. Prepare a report to document work performed, and to describe the results and recommendations of a site and energy audit and the leak detection study.

This study does <u>not</u> include an audit of the potable or raw water system at BAAP.

LEAK DETECTION SURVEY

A leak detection survey was performed on all process water piping with a diameter of 6 inches or greater. The leak detection analysis was performed using a combination of listening devices and preamplified-transducer systems to identify the majority of leak locations. When the location of the leak could not be readily identified using these

methods, a leak correlator was used. The leak correlator determines leak location based on the time it takes for sound to travel from the leak to a waterline connection point.

Sixty-four leaks were identified by the survey on the water mains within the project scope area. The estimated leakage of 194,500 gallons per day (gpd) was separated into the following types of leaks:

- Fifty fire hydrant leaks at 37,500 gpd
- Five main line leaks at 143,000 gpd.
- Eight valve leaks at 11,000 gpd.
- One service line leak at 3,000 gpd.

ENERGY CONSERVATION OPPORTUNITIES

The majority of water usage in the process water system is due to leakage. ECOs were evaluated that would serve to reduce leakage, thereby reducing pumping, chemical treatment, and maintenance costs.

Description of ECOs

Four ECOs were identified to reduce leakage in the process water system. These four ECOs are:

- **ECO #1.** Implement a water audit and leak detection program.

- **ECO #2.** Clean and reline with cement four lines designated by BAAP personnel as having historically high occurrences of leakage.

- **ECO #3.** Isolate piping that is located in areas classified as "Caretaker" areas. "Caretaker" areas consist of a number of buildings identified by BAAP personnel which do not require maintenance. Fire protection would only be provided along the perimeter of "Caretaker" to inhibit the spread of fire to those areas not designated "Caretaker".

- ECO #4. Implement a water audit and leak detection program, taking into account the effects of implementing ECO #2 and #3 on the process water system.

Economic Analysis

The economic analysis of the ECOs is summarized in Table 1.

Table 1. Summary of ECOs

ECO No.	Description	Investment Cost	Annual Water Savings*	Total Disc. Savings	SIR	Payback (yrs)
1	Implement Leak Detection	$20,160	116.73	$524,574	30.34	0.49
2	Reline Design. Main Lines	724,676	54.636	1,278,139	1.76	8.45
3	Isolate Caretaker Areas	71,403	18.73	438,211	6.14	2.43
3A	Isolate Area #8	13,654	2.75	64,374	4.71	3.16
3B	Isolate Area #1	8,324	1.00	23,411	2.81	5.30
3C	Isolate Area #12	5,351	3.13	73,152	13.67	1.09
3D	Isolate Area #13	13,676	1.20	28,143	2.06	7.25
3E	Isolate Area #9	13,589	1.46	34,061	2.51	5.95
3F	Isolate Area #18	16,807	9.20	215,094	12.80	1.17
4	Leak Detection After #2,#3	17,640	61.71	323,356	18.33	0.82

*Annual Water Savings are in units of millions of gallons saved per year

ECO Nos. 1, 2, 3 and 4 all display favorable economic payback. That is, they all have SIRs greater than 1.25 and simple paybacks of 10 years or less. Based on the qualifications listed by the Scope of Work, all of the ECOs qualify for government energy conservation funding programs.

RECOMMENDATIONS

The following ECOs are recommended for implementation:

- **ECO #1. Implement a leak detection program**, including a water audit, every two years as recommended by AWWA Manual 36. Continue with BAAP's policy to immediately excavate and repair all leaks discovered by the leak detection surveys.

- **ECO #2. Clean and reline with cement** the following main lines:

    1. 24-inch diameter pipe that runs along coordinate East 2,023. This section starts at Valve 368 to the north and ends at Valve F-9 to the south. The pipe has a total length of 2,644 feet and supplies 10 branches.

    2. 24-inch diameter pipe that runs along coordinate East 3,013. This section starts at Valve 281 to the north, and ends at Valve F-11 to the south. This pipe has a total length of 2,244 feet and supplies 12 branches.

    3. 14-inch diameter pipe that runs along coordinate East 4,885. This section starts at Valve 268 to the north and ends at Valve 341 to the south. The pipe has a total length of 2,870 feet and supplies 38 service branches.

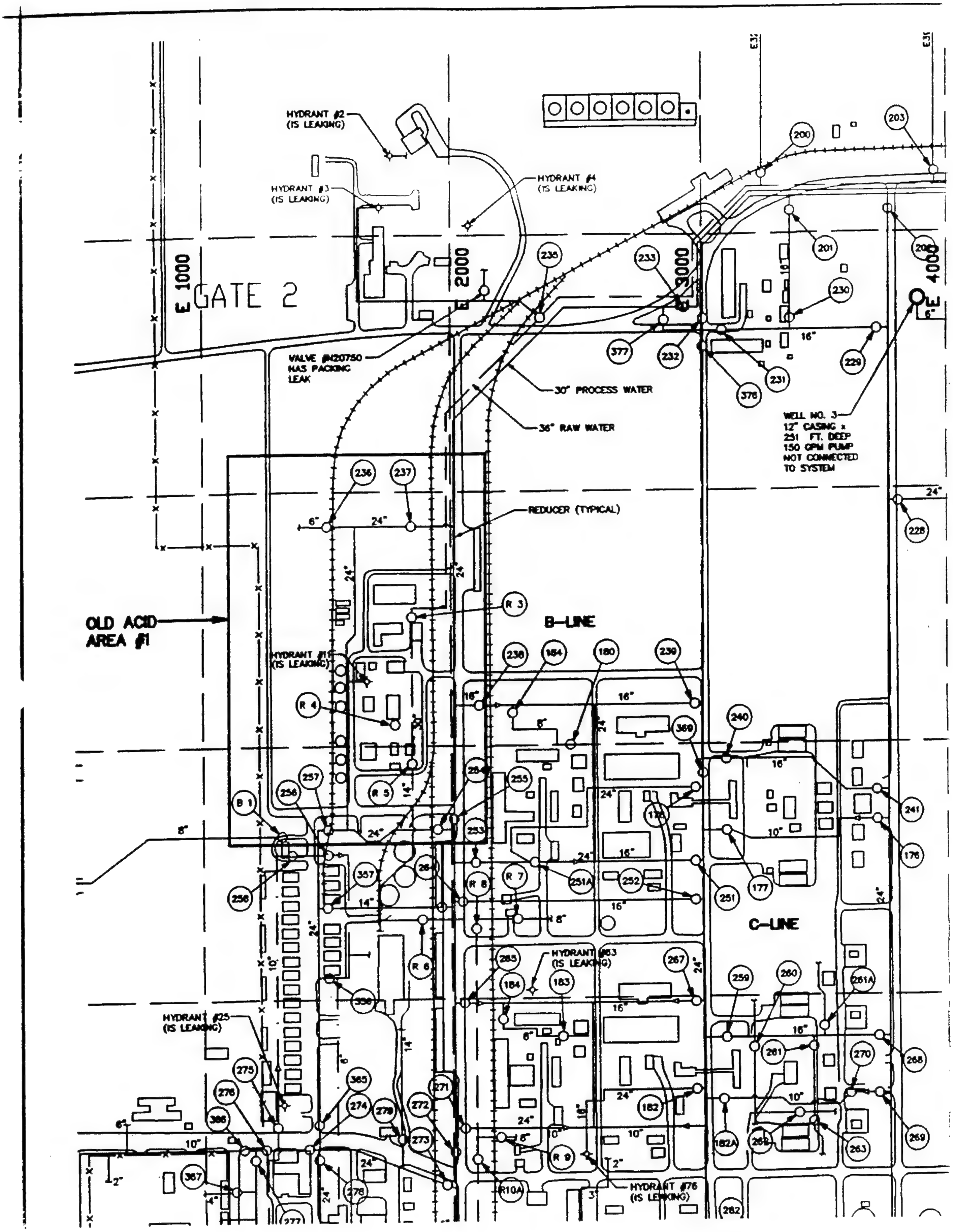
4. 14-inch diameter pipe that runs along coordinate East 4,215. This section starts at Valve 204 to the north and ends at Valve 242 to the south. The pipe has a total length of 2,440 feet and supplies 22 branches.

These pipe lengths were chosen based upon evaluation of leakage frequency by BAAP personnel. The grand total of pipe to be cleaned and relined is 4,890 feet of 24-inch diameter steel pipe, and 5,310 feet of 14-inch diameter steel pipe. See Figures 1 and 2 on the following pages for specific location of these pipe lengths.

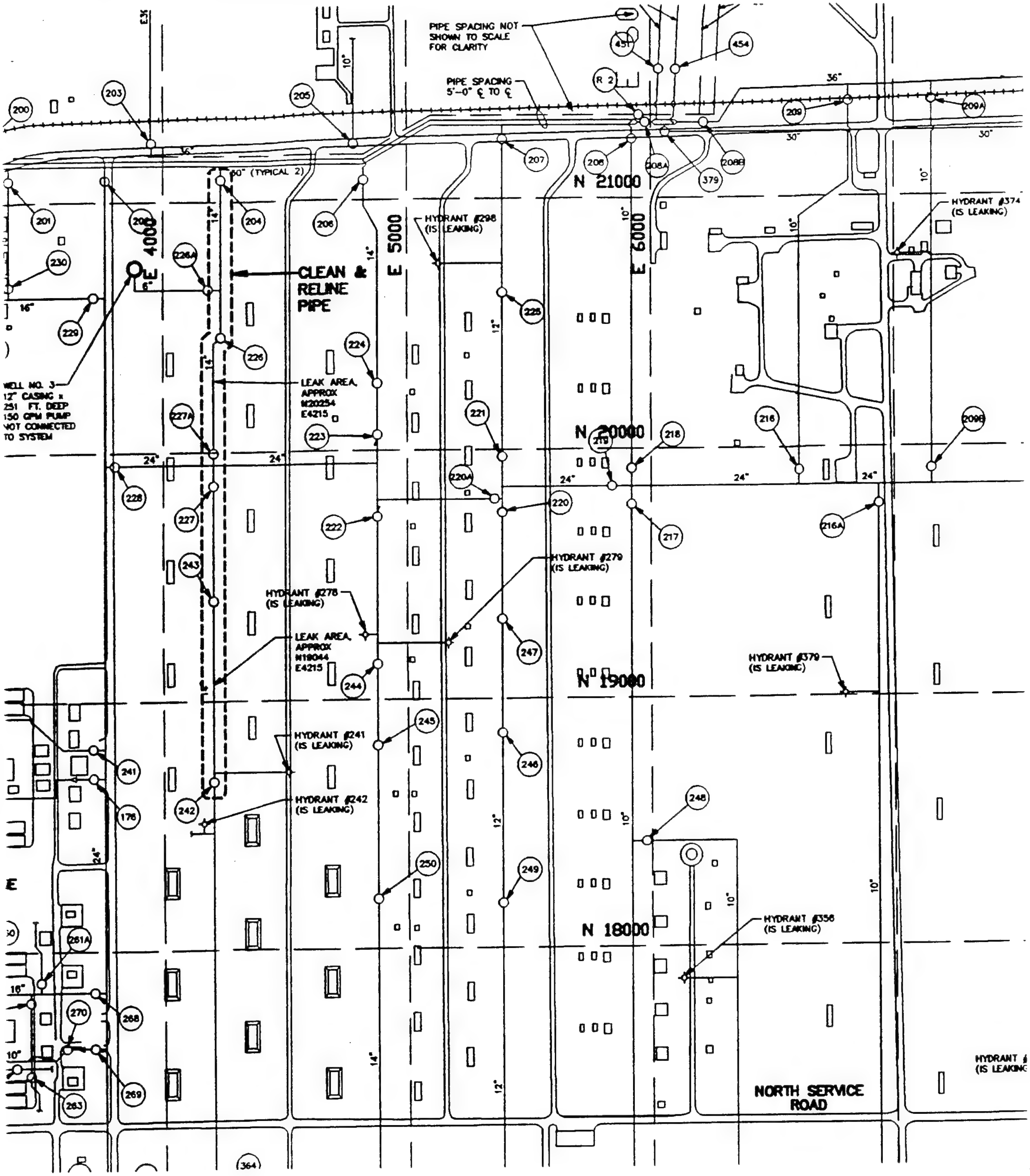
- **ECO #3. Isolate process water piping** in "Caretaker" Area No. 1, 8, 9, 12, 13, and 18. If this ECO is implemented, special care must be taken that the buildings in these areas remain in "Caretaker" status. If, in the future, buildings are taken off "Caretaker" status, fire protection must be restored to those buildings. Figures 1 through 3 illustrate the precise location of the "Caretaker" areas.

- **ECO #4. Implement a leak detection program**, including a water audit, as recommended in ECO #1. However, this ECO should only be considered if ECO #2 and #3 are implemented first.

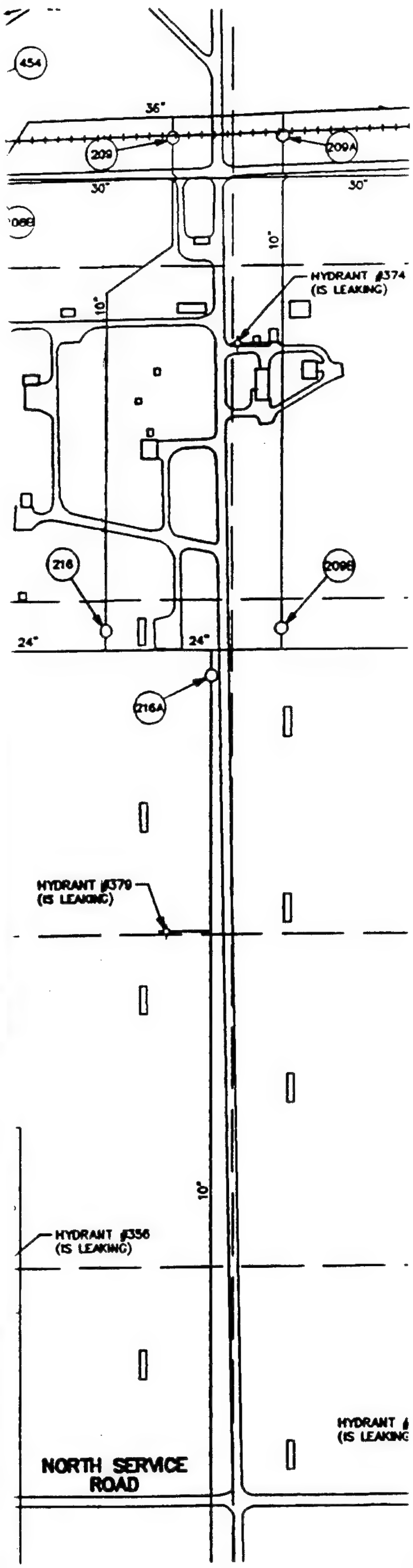
Note that the recommendations and programming documentation for ECO #1 and #4 are identical except that ECO #1 is based on current process water system conditions and EO #4 is based on the estimated condition of the process water system after ECO #2 and #3 are implemented. BAAP personnel should determine the appropriate time to submit either ECO #1 or ECO #4 for government funding.


HYDRANT #2 (IS LEAKING)
HYDRANT #3 (IS LEAKING)
HYDRANT #4 (IS LEAKING)
E 1000
GATE 2
E 2000
E 3000
E 4000
VALVE #N20750 HAS PACKING LEAK
30" PROCESS WATER
36" RAW WATER
WELL NO. 3 12" CASING x 251 FT. DEEP 150 GPM PUMP NOT CONNECTED TO SYSTEM
REDUCER (TYPICAL)
OLD ACID AREA #1
B-LINE
HYDRANT #11 (IS LEAKING)
C-LINE
HYDRANT #63 (IS LEAKING)
HYDRANT #25 (IS LEAKING)
HYDRANT #76 (IS LEAKING)

1


PIPE SPACING NOT SHOWN TO SCALE FOR CLARITY
PIPE SPACING 5'-0" ℄ TO ℄
36"
30"
30" (TYPICAL 2)
N 21000
N 20000
N 19000
N 18000
E 4000
E 5000
E 6000
CLEAN & RELINE PIPE
WELL NO. 3- 12" CASING x 251 FT. DEEP 150 GPM PUMP NOT CONNECTED TO SYSTEM
LEAK AREA, APPROX N20254 E4215
LEAK AREA, APPROX N19044 E4215
HYDRANT #298 (IS LEAKING)
HYDRANT #374 (IS LEAKING)
HYDRANT #279 (IS LEAKING)
HYDRANT #278 (IS LEAKING)
HYDRANT #379 (IS LEAKING)
HYDRANT #241 (IS LEAKING)
HYDRANT #242 (IS LEAKING)
HYDRANT #356 (IS LEAKING)
NORTH SERVICE ROAD
24"
16"
14"
12"
10"
6"

②



N

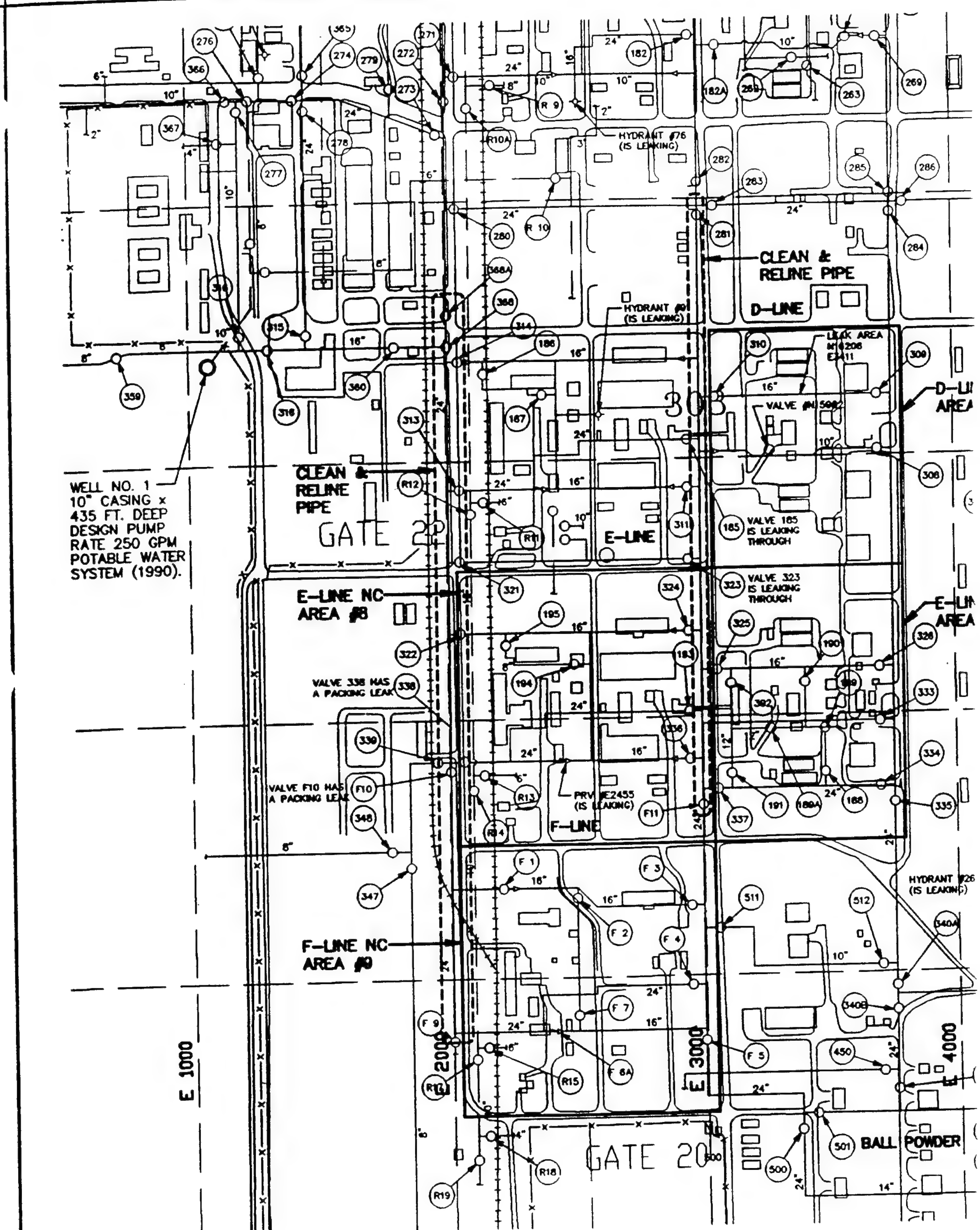
LEGEND

----	LOCATION OF PIPE TO BE RELINED
——	BOUNDARY OF CARETAKER AREA
N20000	COORDINATES
(XXX)	VALVE NO.
12"	PIPE DIAMETER

Figure 1
Process Water Piping for BAAP Northwest

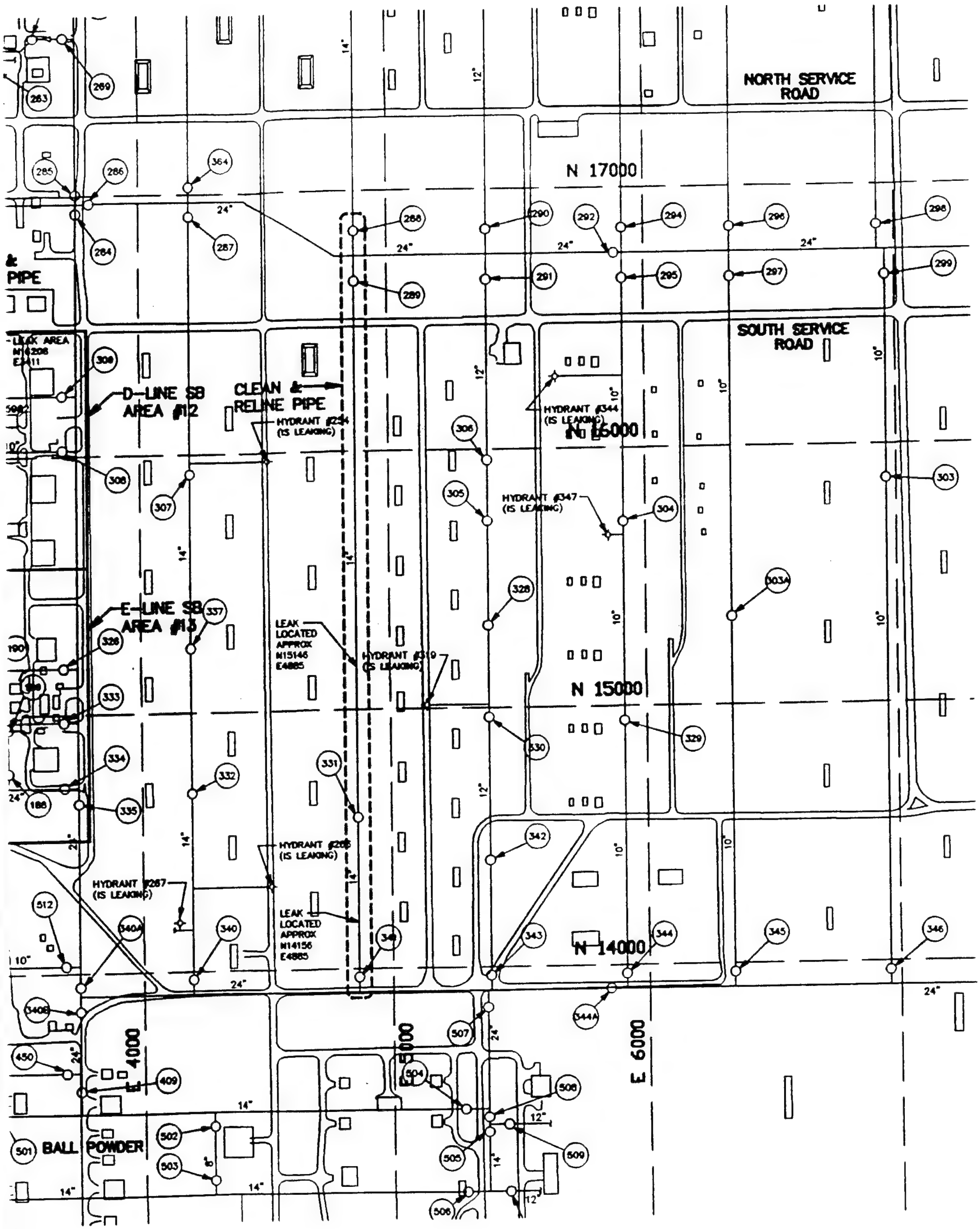
SCALE: 1=500

3



WELL NO. 1
10" CASING x
435 FT. DEEP
DESIGN PUMP
RATE 250 GPM
POTABLE WATER
SYSTEM (1990).
HYDRANT #76
(IS LEAKING)
CLEAN &
RELINE PIPE
D-LINE
HYDRANT #0
(IS LEAKING)
LEAK AREA
VALVE #N 5062
CLEAN &
RELINE
PIPE
GATE 2
E-LINE
VALVE 185
IS LEAKING
THROUGH
VALVE 323
IS LEAKING
THROUGH
E-LINE NC
AREA #8
VALVE 338 HAS
A PACKING LEAK
VALVE F10 HAS
A PACKING LEAK
PRV #E2455
(IS LEAKING)
F-LINE
F-LINE NC
AREA #9
HYDRANT #26
(IS LEAKING)
E 1000
E 2000
E 3000
E 4000
GATE 20
BALL POWDER

D


NORTH SERVICE ROAD
SOUTH SERVICE ROAD
N 17000
N 16000
N 15000
N 14000
E 4000
E 5000
E 6000
& PIPE
LEAK AREA N16208 E3411
D-LINE SB AREA #12
E-LINE SB AREA #13
CLEAN & RELINE PIPE
HYDRANT #254 (IS LEAKING)
HYDRANT #344 (IS LEAKING)
HYDRANT #347 (IS LEAKING)
HYDRANT #319 (IS LEAKING)
HYDRANT #265 (IS LEAKING)
HYDRANT #267 (IS LEAKING)
LEAK LOCATED APPROX N15146 E4865
LEAK LOCATED APPROX N14156 E4865
BALL POWDER
24"
14"
12"
10"
283
289
285
286
364
284
287
288
289
290
291
292
294
295
296
297
298
299
309
306
305
304
303
307
308
328
303A
337
326
333
334
332
335
186
330
329
331
342
343
344
344A
345
346
340
340A
340B
512
450
409
501
502
503
504
505
506
507
508
509

Pr
SCA

(2)

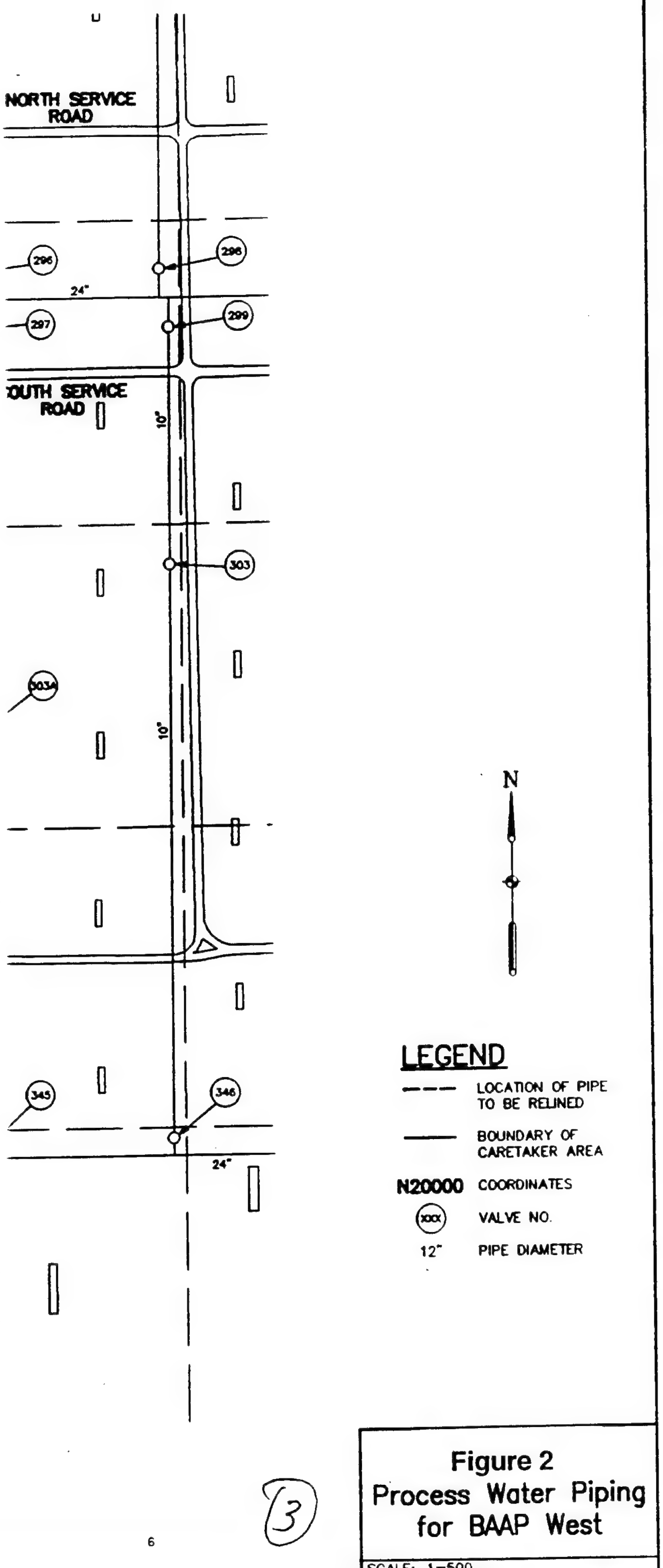
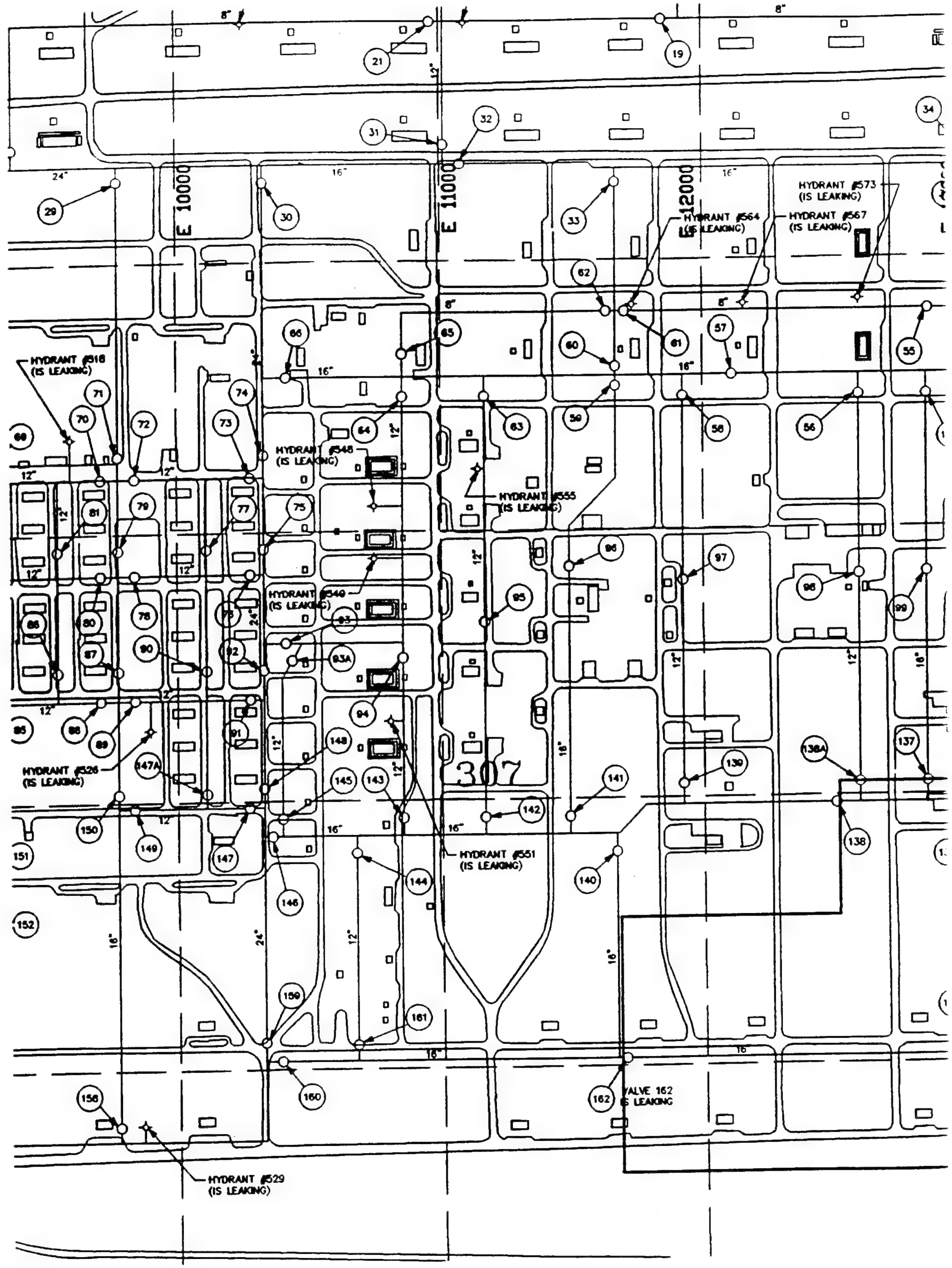
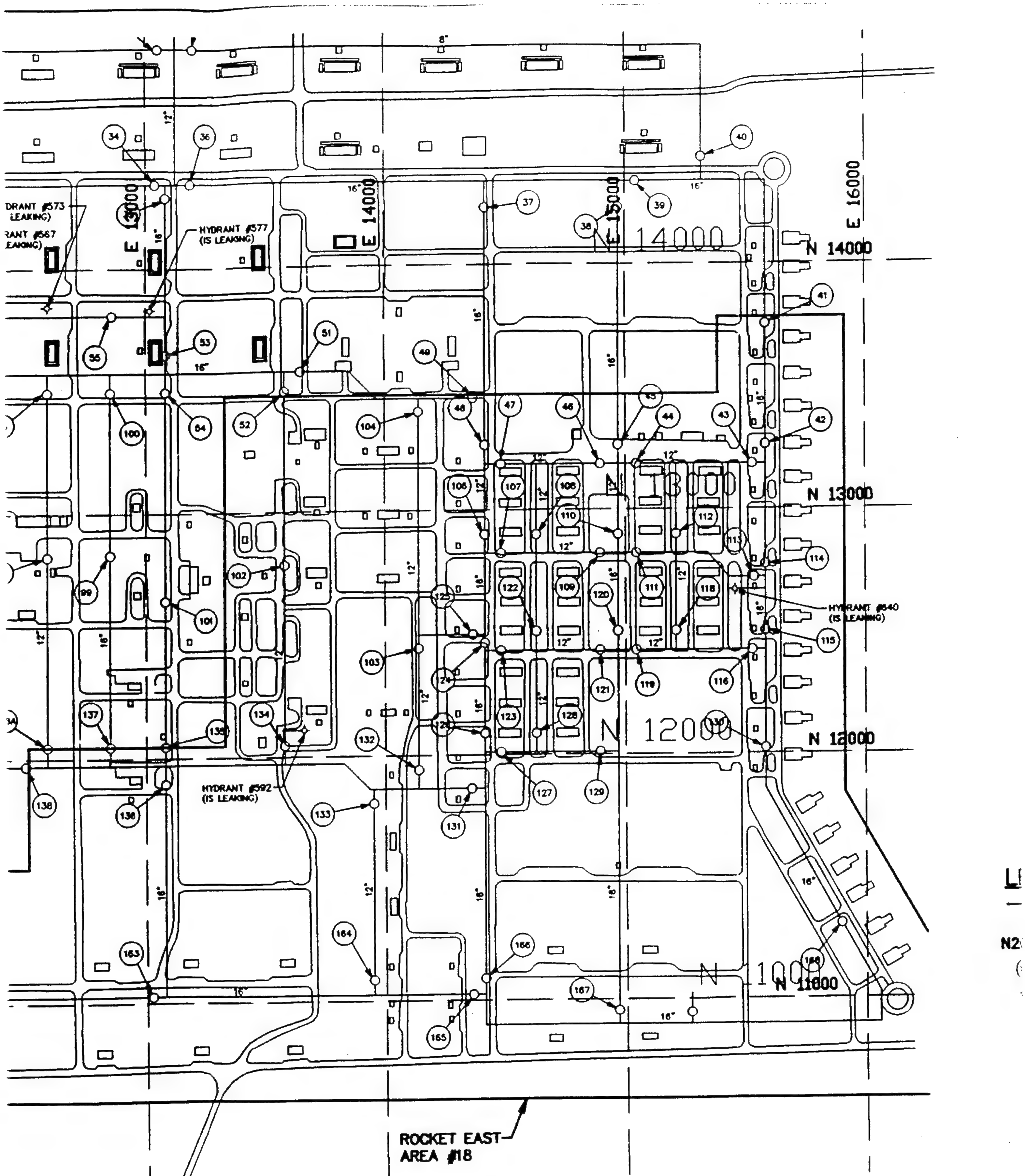


Figure 2
Process Water Piping for BAAP West

SCALE: 1=500


E 10000
E 11000
E 12000
HYDRANT #573
(IS LEAKING)
HYDRANT #564
(IS LEAKING)
HYDRANT #567
(IS LEAKING)
HYDRANT #516
(IS LEAKING)
HYDRANT #548
(IS LEAKING)
HYDRANT #555
(IS LEAKING)
HYDRANT #549
(IS LEAKING)
HYDRANT #526
(IS LEAKING)
HYDRANT #551
(IS LEAKING)
VALVE 162
IS LEAKING
HYDRANT #529
(IS LEAKING)
307

(1)



(2)

Proc
BAAP
SCALE:

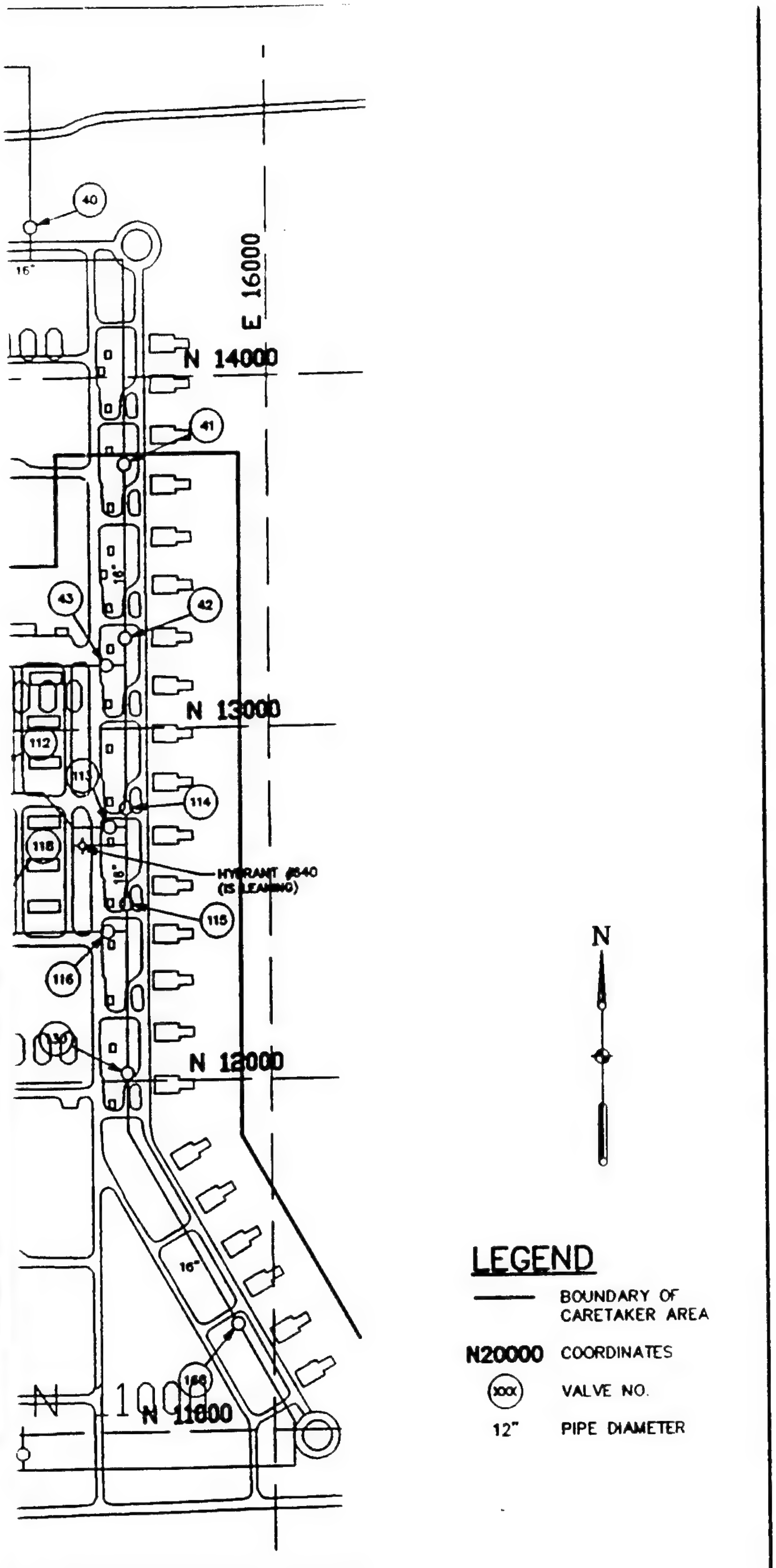


Figure 3
Process Water Piping for BAAP Rocket Area East

SCALE: 1=500

3

1. INTRODUCTION

1.1 AUTHORITY FOR STUDY

This study was conducted and this report prepared under Contract No. DACA01-94-D-0033, Delivery Order No. 0004. The contract was issued by the Department of the Army, Mobile District, Corps of Engineers, to E M C Engineers, Inc. (EMC).

1.2 PURPOSE OF STUDY

The purpose of this water conservation study is to identify projects which will result in energy, maintenance, and cost savings in the process water distribution system at Badger Army Ammunition Plant (BAAP) in Baraboo, Wisconsin. The study will present information obtained during an audit and leak detection study of the process water system. The study will also make recommendations for corrective actions that could result in energy, operational and maintenance savings. Recommendations presented by this study are based strictly on economic feasibility and life cycle cost analysis.

This study does <u>not</u> include an audit of the potable or raw water system at BAAP.

1.3 BACKGROUND

Badger Army Ammunition Plant (BAAP) is located nine miles south of Baraboo, Wisconsin, which is approximately fifty miles north of Madison. The government facility was constructed in the 1940s to provide military propellants and explosives in support of World War II.

BAAP is currently being operated in "standby" status by a contractor. Excerpts from the plant's current mission statement, dated 17 April 1990, include:

- "Operation and maintenance of active facilities in support of current operations. Maintenance and/or layaway of standby facilities...in condition to permit rehabilitation and resumption of production within prescribed time limitations."

- "Receipt, surveillance, maintenance, renovation, storage, physical inventory, issue, demilitarization, and salvage of field service stocks, items of industrial stocks, and international logistics requirement stocks."

- "Custodial maintenance and administrative functions of subinstallations."

- "Provide a fire prevention and protection program in compliance with applicable regulations and contract requirements."

- "Provide and promote an energy conservation program."

A copy of the full mission statement for BAAP is given in Appendix A.

BAAP is served by three multi-looped water distribution systems which are supplied by four functioning groundwater wells or the Wisconsin River. The following is a brief description of each system.

- **Raw Water System.** This system provides raw water from the Wisconsin River to a number of production areas for the purpose of cooling processes. Because these production areas are currently inactive, the raw water system is not being used.

- **Potable Water System.** This system was recently modified to exclusively serve the administrative and shop areas. The system provides up to 250 daytime workers with approximately 10,000 gallons of water per day. Well No. 1 supplies this system and uses a pressure tank for storage. The groundwater is disinfected through chlorination at the well site. A fractional horsepower chemical feed pump discharges chlorine directly into the pump discharge pipe.

  A recent construction project connected Well No. 2 with the potable water system and completely isolated the potable and process water systems. Well No. 2, which until a few months ago supplemented the process water system, now serves only as a backup to Well No. 1.

- **Process Water System.** Process water is distributed throughout BAAP by approximately 120 miles of piping. The process water system consists mainly of cast iron piping with large main lines (14 inch to 36 inch diameter) constructed of steel. During the production years, this system supplied both the process (production) water needs and the potable water needs, but did not supply raw water. Since production has ceased, the system serves the fire protection requirements at BAAP.

  Currently, the main source of process water is Well No. 4, which pumps treated water into the piping network and to a five million gallon open reservoir for storage. Well No. 4 is manually controlled by a time clock to maintain the reservoir level. Well No. 5 serves as a backup to Well No. 4, but is infrequently used.

  Approximately 95% of the total water used at BAAP is from the process water system. Although some water is used for hydrant testing, minor industrial uses, and irrigation, the great majority of the water is lost to leakage.

Under a current contract, the Corps of Engineers is constructing a 10 inch pipeline from the existing Pump and Treat (IRM) Facility to the process water system. Once completed the IRM Facility will supply treated groundwater to the process water system at a rate of 500 gpm. The wells will then be used to supplement the IRM Facility when the process water system requires more than 500 gpm or when the IRM Facility is down for maintenance.

1.4 SCOPE OF WORK

The Scope of Work (SOW) for this project is included in Appendix A of this report. The major technical criteria identified by the SOW are:

- Perform a site survey for the purposes of the familiarization of BAAP's water systems. Sufficient information should be collected to allow for an adequate evaluation of the water systems and to identify possible ECOs. This information would include as-built drawings, historical usage data, and interviews of on-site personnel.

- Perform an underground leak detection survey on all process water piping 6 inch and larger at BAAP. The survey should identify the location, type and quantity of all discovered leaks.

- Prepare a map of the BAAP process water system showing the locations and estimated quantities of leaks.

- Evaluate identified ECOs to determine their energy savings potential and economic feasibility.

- Provide project documentation for recommended ECOs.

- Prepare a report to document work performed and to describe the results and recommendations of the site and energy audit and the leak detection study.

1.5 APPROACH

The approach taken in this study is as follows:

1. **Field Survey.** The process water system at BAAP was examined to gain an understanding of system operation and maintenance and to determine the condition of the system. Information such as pump nameplate data, as-built drawings, and historical meter data was obtained. On-site personnel were interviewed to ascertain

system operation and to define unacceptable conditions, past problems, and future requirements.

2. **Leak Detection Survey**. A survey of all process water piping 6 inch in diameter and larger was performed to determine the location, type, and quantity of leaks.

3. **Analysis of Leak Detection Survey**. Data from the leak detection survey was summarized. The location and quantity of each leak was transferred to BAAP water system maps prepared for this report.

4. **ECO Analysis.** Appropriate ECOs were identified and analyzed to determine their economic feasibility. Economic feasibility was judged as a comparison between the investment cost of implementing the ECO and the savings that would result. Cost savings were calculated as the sum of reduced pumping, water treatment, and maintenance costs as a result of reduced water consumption. Criteria outlined by the Energy Conservation Investment Program (ECIP) was used to define economic feasibility. A recommended ECO must have a savings-to-investment ratio (SIR) of 1.25 or better and a simple payback (SPB) of 10 years or less to be considered.

5. **Interim Report and Review**. The results of the field and leak detection survey, as well as the identification and analysis of ECOs, were presented in the interim report. The ECOs were to be organized into the form of possible ECIP projects. The results of the governmental review were incorporated into the Final Report.

6. **Final Report**. The incorporation of programming documentation, client comments, and the interim report will constitute the final report. Programming documentation will be prepared according to direction given by the client, based on recommendations outlined by the interim report.

2. DESCRIPTION OF EXISTING CONDITIONS

2.1 GENERAL

During the week of 17 October, 1994, a field survey was performed by EMC to obtain the necessary information to identify and evaluate possible energy conservation opportunities (ECOs) for the process water system at BAAP. It was found that the majority of water consumption in the process water system is due to leaks in distribution piping, valves, and fire hydrants. Therefore, the ECOs would seek to reduce water consumption by reducing the amount of leakage. The energy savings resulting from implementing the ECOs would result in reduced pumping, water treatment, and maintenance costs.

2.1.1 History of Process Water System

The majority of the distribution system was built during the original 1942-1945 construction of the plant. The facility was upgraded in 1954 with the construction of the Ball Powder Propellant Area, which became necessary due to the Korean Conflict. Since 1972, modernization of the BAAP has been responsible for the construction of a new Acid Area, new Nitroglycerin Area, a Contaminated Waste Processor, Temporary Waste Acid Disposal Facility, and an Alcohol-Ether Facility. The process water distribution system has been expanded along with these new facilities to meet the process water and fire protection requirements.

Currently, Well No. 4 is the primary source of process water with Well No. 5 used as a backup. In the past, Well No. 2 was also used to supplement the process water system as needed. Health concerns about cross-connections of the potable and process water systems as well as the uncovered reservoir led to the construction of a completely separate potable water system. The construction project was completed last year by converting Well No. 2 to an independent source of potable water. The potable water system now uses Well No. 2 as a backup source, while Well No. 1 continues to be the primary source of potable water. Well No. 3 is currently used by the U.S. Geological Survey, Water Resources Division, to continuously monitor local groundwater conditions.

2.1.2 Description of Buildings Served

BAAP has been in standby status since 1975. Many of the buildings are not being utilized and their status is not anticipated to change in the near future. BAAP has classified these buildings, located in eighteen separate areas, as having "Caretaker" status. By definition and from conversations with BAAP personnel, it is assumed that their value has depreciated to the point that fire protection is not required. A complete listing of all buildings with "Caretaker" status, provided by BAAP personnel, is listed in Appendix B.

2.1.3 Description of Process Water Piping System

Over 116 miles of process water piping serve BAAP, in diameters ranging from 1 inch to 36 inch. The distribution system consists mainly of cast iron piping, with the larger main lines (14 inch to 36 inch) constructed mostly of steel. Other types of piping installed include PVC, spiral wound and asbestos cement pipes. A detailed summary of the estimated lengths of different size piping is listed in Appendix B.

Process water is chlorinated at the well head, pumped from groundwater wells into the process water piping system, and stored in a five million gallon open reservoir. The wells are controlled so that the reservoir level is maintained. System pressures are maintained at approximately 65 to 75 psig.

2.1.4 Description of Wells

There are five wells located at BAAP which are or have been used in the production of water for facility use. Wells No. 1 and 2 supply water to the separate potable water system. Well No. 3 is used as a monitoring well. Wells No. 4 and No. 5 supply water to the process water system. Nameplate data for Wells No. 4 and 5 is given in Table 2-1.

Table 2-1. Process Water Well Nameplate Data

Well No.	Pump Type	Motor Manufacturer	Motor Size (hp)	Pump Capacity (gpm)
4	Line Shaft Turbine	General Electric	100	935
5	Line Shaft Turbine	U.S. Electric	200	1300

Well No. 4 is manually controlled to operate by a time clock. The time clock is set to start at 5:15 p.m. and shut off at 6:15 a.m. The wells are manually operated by BAAP personnel to maintain the reservoir level. Review of maintenance logs provided by BAAP personnel suggested that Well No. 4 operated under a near-normal schedule over the past year. Operation was modified only a few times for sampling and maintenance activities and for a few minor line breaks.

Historical water meter data indicates that the wells have pumped at a cumulatively constant rate over the previous years. Water usage rates for the last three years are summarized in Table 2-2.

Table 2-2. Water Usage Rates (Gal/Yr)

Year	Well No. 1	Well No. 2	Well No. 4
1992	4,921,525	86,899,575	178,666,690
1993	4,524,025	71,638,525	163,458,465
1994*	6,021,433	54,894,800	178,853,400
Average	5,155,661	77,243,722	173,659,518

*1994 Data was only provided from January through September. Partial data was extrapolated for full year.

A detailed summary of monthly water usage can be found in Appendix B. The monthly data clearly shows that Well No. 2 has supplemented Well No. 4 over the years, providing approximately 30% of the water used by the process water system. The process water system uses, on average, 250,900,000 gallons of water per year. This translates to a usage rate of almost 687,400 gallons per day.

2.1.5 Pump and Treat (IRM) Facility

Under a current contract, the Corps of Engineers is constructing a 10 inch pipeline from the existing Pump and Treat (IRM) Facility to the process water system. The IRM Facility presently treats 500 gpm of contaminated groundwater on the south end of the BAAP burning grounds. The treated water is currently pumped from the IRM Facility to the Wisconsin River. After completion of the 10 inch pipeline and the replacement of one of the 20 hp pumps with a 40 hp pump at the IRM Facility, the treated water will either be sent to the process water system or to the river.

For the purposes of this report, it will be assumed that the IRM Facility will be the main source of water to the process water system. It will be assumed that the IRM Facility will operate 24 hours per day, producing 500 gpm (21,960,000 gallons per month). According to historic meter data, process water demand has exceeded 21,960,000 gallons per month about four months out of the year (on average). Calculations conservatively estimate that the wells will have to produce about 14,000,000 gallons per year to fully supplement the IRM Facility. At 935 gpm, this translates into an annual operating duration of 250 hours per year. In order for the IRM Facility to produce the remaining 236,900,000 gallons at 500 gpm, the pumps must operate approximately 7,900 hours per year. Detailed calculations of the annual operating hours for the IRM Facility and the wells are located in Appendix D.

2.2 LEAK DETECTION SURVEY

A leak detection survey was performed on all process water piping with a diameter of 6 inches or greater. M.E. Simpson (MES) of Valparaiso, Indiana, was contracted by EMC to perform the leak detection analysis.

2.2.1 Method of Analysis

MES used a combination of listening devices and preamplified-transducer systems to identify the majority of leak locations during the leak detection survey. When identification of the leaks proved difficult by these means they used a leak computer called a leak correlator to identify the leak location.

Using the listening devices and the transducers set up on fire hydrants and valve boxes, as appropriate, they "listened" for leaks in the system. The audible noises created when water escapes from a pipe, valve or hydrant can be deciphered as to the source of the leak.

When water escapes from an orifice, it causes a vibration in the 500-800 Hz range. This sound travels along the pipe wall and can be heard a considerable distance away by an observer with the proper equipment. Other sounds (in the 25-250 Hz range) are caused by water striking the soil and swirling around in the cavity it creates. This sound does not travel well along the pipe, and is therefore useful in pinpointing the leak (Walski, 1984)

When the source of the noise was located on a main line, an excavating crew was brought in to excavate the leak. A comparison was made between the actual leak rate and the rate estimated from listening to the leakage noise. This fine tuning is required to estimate the size of the leaks as the noise/leak rate correlation may change from project to project.

The correlator is used when the leak location(s) are not readily identified by the above methods. The correlator is connected to the waterline at two points. The microprocessor units measure the time it takes for the sound to travel from the leak to the waterline connection point. Since the correlators are connected to the waterline at two points, the leak location can be identified.

2.2.2 Summary of Results

The water mains within the project scope area were surveyed and sixty-four leaks were located. The total leakage quantity was estimated to be 194,500 gallons per day. The leakage quantity is made up of:

- Fifty fire hydrant leaks at 37,500 gpd.
- Eleven valve leaks at 11,000 gpd.
- One service line leak at 3,000 gpd.
- Five main line leaks at approximately 143,000 gpd.

A breakdown of the leakage results and locations of the leaks is contained in Appendix C.

2.3 CONDITION OF PROCESS WATER PIPING SYSTEM

2.3.1 General

BAAP currently utilizes a three-man maintenance crew to repair leakage in the distribution system. Because of their efforts, water usage remains relatively constant. This would suggest that new leaks occur at the same rate that old leaks are repaired. During the field survey, a 24 inch water main was examined while it was being repaired. The survey team counted 14 patches along its 15 feet of exposed length. When asked why this section of piping wasn't replaced, BAAP personnel responded that the entire length of pipe looked similar.

A leak detection survey (Pitometer Associates, 1990) completed in 1990 identified 202,000 gpd of leakage in the distribution system at BAAP. This would suggest the following:

- Total leakage in the system has remained relatively constant over the last five years. Therefore, ECOs should be identified that will serve to eliminate future as well as identified current leakage.

- A regular leak detection survey, at least every two years, would be a necessary tool in identifying any new leakage in the distribution system which hasn't already been revealed on the surface.

2.3.2 Piping Designated by BAAP

BAAP personnel supplied a list of main lines that have a history of high leakage rates, such as the 24 inch water main described above. The main lines identified are listed in Table 2-3.

Table 2-3. BAAP-Designated Piping in Poor Condition

Pipe Dia.	Coordinate Location	Starting At	Ending At	Total Length (ft)	No. of Branches
24″	East 2,023	Valve #368	Valve #F-9	2,644	10
24″	East 3,013	Valve 281	Valve #F-11	2,244	12
14″	East 4,885	Valve #206	Valve #341	2,870	38
14″	East, 4,215	Valve #204	Valve #242	2,440	22

Patching main leaks on these pipes is merely a temporary solution. A relatively permanent solution would be to replace the pipe lines or reline these pipes with cement. The permanent solutions are more economically feasible because it would eliminate maintenance costs as well as reduce pumping costs.

Figures 2-1 and 2-2 on page 2-7 and 2-8 illustrate the locations of the lines designated by BAAP personnel.

2.3.3 Leaks Occurring in "Caretaker" Areas

Of the sixty-four leaks identified in the study, ten occur in piping that serve buildings in "Caretaker" status. These ten leaks are made up of the following:

- Six fire hydrant leaks at 4,500 gpd
- One main line leak at 3,000 gpd
- Three valve leaks at 4,750 gpd

It may be economically feasible to cap off piping that exclusively serves "Caretaker" buildings. Not only would the current leakage amount of 12,500 gpd be saved, all future leakage in those areas would also be eliminated. There are eighteen areas identified by BAAP as containing buildings with "Caretaker" status. Six areas were identified where piping serves "Caretaker" buildings only.

- Area #8 (E-Line Nitrocellulose Area)
- Area #1 (Old Acid Area)
- Area #12 (West Section of D-Line Single Baseline Area)
- Area #13 (West Section of E-Line Single Baseline Area)
- Area #9 (F-Line Nitrocellulose Area)
- Area #18 (Rocket East).

Figures 2-1 through 2-3 on the following pages illustrate the precise location of the "Caretaker" areas.

3. WATER SYSTEM ENERGY AUDIT

The purpose of this energy audit is to investigate possible energy conservation opportunities (ECOs) to be implemented in the process water system at BAAP. Energy savings can be achieved by reducing the quantity of process water pumped from the IRM Facility and Wells No. 4 and 5. The majority of water usage and, therefore, pumping for the process water system is a result of leaking pipes, hydrants, and valves. Reducing the leakage will contribute to energy and cost savings in several ways:

- **Pump Electrical Consumption.** Reducing water leakage will decrease the amount of electrical consumption required by process water system pumps.

- **Well Maintenance.** Decreased operating time for the well pumps will reduce the amount of maintenance required on pumps and pump motors.

- **Distribution System Maintenance.** If leakage can be reduced in the distribution system, fewer labor hours will be needed to locate and repair leakage.

- **Chemical Treatment.** If water usage can be reduced, the amount of chemicals (chlorine) required to treat the process water will also be reduced.

3.1 ENERGY AND MAINTENANCE COSTS

Projects that are analyzed using the Energy Conservation Investment Program (ECIP) criteria must differentiate between energy and non-energy savings because different discount rates apply to each. Therefore, electrical, maintenance, and chemical treatment savings were calculated separately in units of cost per gallon of leakage saved.

Energy and maintenance costs are related to the amount of process water pumped so that leakage savings can be translated into cost savings. These cost ratios are based on the total amount of process water pumped. Recent modifications to the potable water system have caused changes in the sources of potable and process water. For example, Well No. 2, once used to supplement the process water system (Well No. 4), is now a backup system for the potable water system (Well No. 1). In addition, Well No. 4 will soon be used to supplement water supplied from the IRM Facility.

Despite these changes, water usage due to leaks in the distribution system have not changed significantly. For this report it was assumed that the 40 hp, 500 gpm capacity pump at the IRM Facility will operate 7,900 hours to supply 236,900,000 gallons per year to the process water system. As stated in Section 2.1.5, the 500 gpm pump will not be able to supply enough water during months with peak demands over 21,960,000 gallons. Therefore, Well No. 4 must be used to supplement process water supply during the peak months. Well No. 4, which produces 935 gpm with a 100 hp motor, will supply the

remaining 14,000,000 gallon demand, operating about 250 hours per year. Well No. 4 will also be used as a backup source of process water when the IRM Facility pump is down for maintenance reasons.

3.1.1 Energy Costs

Electrical rates at BAAP were based on historical electric bills from Wisconsin Power and Light Company. They include the following charges:

- **Electric Demand.** $6.82 per kW. The demand usage from the pump motors was calculated using the following equation:

$$Demand\ (kW) = \frac{(HP)(0.746)(LF)(Months)}{EFFM}$$

where

HP	=	nameplate horsepower,
0.746	=	conversion factor relating kilowatts to horsepower,
LF	=	load factor (assume 75% average),
EFFM	=	motor efficiency, and
months	=	numbers of months that the motors contribute to demand charges.

It was assumed that the IRM Facility pumps will contribute to demand charges 12 months per year while the well pump contributes only four months per year.

- **Electrical Consumption:** $0.0374 per kWh. This charge was based on the average cost per kWh over the last three years. Electricity consumed by the pumps was calculated using the following equation:

$$Consumption\ (kWh) = Demand\ (kW) \times Annual\ operating\ hours\ (hrs)\,.$$

- **Electric Cost per Water Usage.** As stated in Section 3.1, the total electric cost will be based on the amount of water pumped. It was assumed for this report that the IRM Facility will supply 236,900,000 gallons per year while Well No. 4 will supply the remaining 14,000,000 gallons per year. Table 3-1 summarizes the electrical consumption and water usage for the IRM Facility pumps and Well No. 4.

Table 3-1. Process Water System Pump Characteristics

	IRM Facility	Well No. 4
Pump Motor Size (hp)	40	100
Motor Efficiency	89.5%	91.7%
Pump Electric Demand (kW)	25.0	61.1
Annual Operating Hours	7,900	250
Pump Annual Electric Consumption (kWh)	197,500	15,275
Water Usage (mil. gal. per yr)	236.9	14.0
Percentage of Process Water Supplied	94.4	5.6
Electrical Cost ($ per 1000 gal)	$0.0398	$0.160

Based on these figures and applying the electrical consumption cost proportionately to both pumps based on percentage of water pumped, the electrical consumption of the pumps at the IRM Facility and at Well No. 4 was calculated to be $0.047 per 1,000 gallons.

A detailed analysis of energy cost calculations can be found in Appendix D.

3.1.2 Maintenance Costs

Maintenance costs were based on information provided by BAAP personnel. Total annual budgeted costs for well and distribution maintenance and chemical treatment were received for all wells. Maintenance costs for the process water system were calculated as the percentage of total budget applied to process water divided by the quantity of water used. Table 3-2 summarizes the average daily water usage of all wells during the period indicated.

Table 3-2. Total Well Water Usage (1992-September 1994)

Well No.	End User	Usage (gpd)	Percentage
1	Potable Water	14,125	2.0
2	*Process Water	211,625	30.2
3	Monitoring Well	0	0.0
4	Process Water	475,780	67.8
5	**Not Used	0	0.0
Total	**-**	**701,530**	**100.0**

*Well No. 2 was converted on 6/94 to be a backup pump for the potable water system (Well No. 1).
**Well No. 5 was recently converted to be a backup for the process water system (Well No. 4).

According to meter data for Jan. 1992 to Sep. 1994, the process water system, consisting previously of Wells No. 2 and No. 4, contributed 98% of the total water pumped by all wells. However, some of the maintenance budget is applied equally to all wells. Therefore,

it was decided by BAAP personnel that about 90% of the total maintenance budget should be applied to the process water system.

Maintenance costs were separated into the following:

- **Well Maintenance.** The total annual budget for well maintenance was given as $75,000. The budget includes funds for well maintenance, operating supplies, overhead, sampling, and miscellaneous operating expenses. The value for well maintenance for the process water system was calculated by taking 90% of the total budget and dividing by the total process water usage. Well maintenance was calculated to be <u>$0.27 per 1,000 gallons</u>.

- **Distribution System Maintenance.** The average cost of distribution system maintenance over the last three years was $339,845. Distribution system maintenance consists mainly of repairing water leaks. The value for distribution maintenance for the process water system was calculated to be <u>$1.22 per 1,000 gallons</u>.

- **Chemical Treatment.** The annual budget for chlorine was given as $9,000. The value for chemical treatment of process water was calculated to be <u>$0.032 per 1,000 gallons</u>.

Each of these values are applied to a Life Cycle Cost Analysis as annual recurring cost savings for the amount of water that is saved by repairing leaks. A detailed analysis of these energy and maintenance cost calculations can be found in Appendix D.

3.1.3 Potential Future Costs

The calculation of a life cycle cost requires that any future cost savings incurred as a result of ECO implementation must be accounted for. In the case of this study, some methods recommended by ECOs may serve to stop potential as well as current leakage. Potential leakage that is eliminated translates into an energy and maintenance cost savings, and serves to improve the economic feasibility of the ECO.

In order to predict the amount of leakage that would be saved in the future, a leakage density was calculated per linear foot of specific diameters of pipe. The leakage density factor was calculated using the total anticipated recoverable leakage in the system (319,820 gpd) (see Section 3.3.1), and dividing by the total length of pipe (for each diameter). The total quantity of specific diameters of pipe from 1" to 48" was given by BAAP personnel. Using the available information, a leakage density factor of <u>0.046 gpd per linear foot per inch diameter of pipe</u> was calculated. Potential future leakage for a specific length and diameter of pipe can now be predicted. The quantity of future leakage can then be translated into an energy and maintenance cost savings. These cost savings can be incorporated into a Life Cycle Cost Analysis.

A detailed analysis of leakage density calculations can be found in Appendix D.

3.2 LIFE CYCLE COST ANALYSIS METHODOLOGY

Economic analysis was performed in accordance to the January 1994 ECIP guide. Uniform present worth factors are based on a 3.0% discount factor and were taken from Table 2, Census Region 2 (Wisconsin), of the NISTIR 85-3273-9, *Energy Price Indices and Discount Factors for Life-Cycle Cost Analysis (Oct. 1994).* Uniform present worth (UPW) factors for non-energy costs were taken from Table A-2. The economic life of equipment was taken from Appendix B of the ECIP guide. A copy of the life cycle discount factors can be found in Appendix D.

ECO construction costs were taken from Means Site Work Cost Data and contractor quotes. Location factors for Madison, Wisconsin, were applied to all material and labor costs. Additional markups used for the LCCA include 20% for overhead and bond, 10% for profit, 10% for contingency, 6% for SIOH, and 6% for design costs.

3.3 ENERGY CONSERVATION OPPORTUNITIES

The following ECOs were evaluated for the process water system:

- **ECO #1.** Implement a water audit and leak detection program.

- **ECO #2.** Clean and reline with cement four sections of pipe designated by BAAP personnel as having historically high occurrences of leakage.

- **ECO #3.** Isolate piping that is located in areas classified as "Caretaker" areas. Fire protection should only be provided along the perimeter of "Caretaker" areas so that a fire does not spread.

- ECO #4. Implement a water audit and leak detection program, taking into account the effects of implementing ECO #2 and #3 on the process water system.

3.3.1 ECO #1: Implement Leak Detection Program

Proposed Modifications: Implement a water audit followed by a leak detection program on a regular basis.

Existing Conditions: A water audit was performed on the process water system according to guidelines set by the American Water Works Association (AWWA) Manual 36, "Water Audits and Leak Detection." The audit was based on information supplied by BAAP. Water usage in the process water system can be separated into the following categories:

- **Fire Hydrants.** Each hydrant is exercised for approximately 10 minutes each summer. There are approximately 675 hydrants that serve BAAP.

- **Industrial Uses.** Process water is still used to produce steam in boilers, as a once-through cooling system, for some domestic water uses, and for some maintenance activities (such as tank cleaning).

- **Irrigation Water for Cattle.** In the summer months water is taken from a hydrant and used as a water supply for cattle.

- **Discovered leaks.** BAAP has a team of maintenance personnel that fix leakage in the process water system large enough to be discovered. Approximately 63 leaks were fixed last year, 80% of them located in the main pipelines.

- **Reservoir evaporation.** The process water system uses an open reservoir for storage. The amount of water that evaporates off the reservoir surface was calculated using pan evaporation data from NOAA Technical Reports NWS 33 and 34.

Table 3-3 summarizes the results of the water audit of the process water system.

Table 3-3 Water Audit Results

Process Water Uses	Gallons Per Year
Fire Hydrants	13,500,000
Industrial Uses	
Boilers	3,900,000
Cooling system	21,100,000
Domestic Uses	6,300,000
Maintenance Activities	2,500,000
Irrigation (cattle)	2,400,000
Discovered leakage	44,323,200
Reservoir evaporation	1,231,700
Total Identified Water Losses	**95,254,900**
Potential water system leakage	
Recoverable	116,733,825
Unrecoverable	38,911,275
Total Amount of Water Pumped	**250,900,000**

Method of Analysis: Analysis proceeded as follows:

- A water audit was performed on the process water system according to AWWA Manual 36. All water usage in the audit was based on information obtained from BAAP personnel.

- The amount of recoverable leakage was estimated. According to AWWA Manual 36, recoverable leakage is defined as approximately 75% of all potential losses in the system. It was assumed that all potential losses which are equal to the total amount of water pumped minus the process water uses outlined in Table 3-3, can be fully attributed to leakage. This assumption was confirmed by BAAP personnel.

- The total beneficial cost of repairing recoverable leakage was calculated. The cost of water was assumed to be the costs that vary with the amount of water delivered to the process water system. These include well maintenance costs, energy costs to pump the water and chemical treatment costs to treat the water. Distribution maintenance costs were not included because they are budgeted, fixed costs. The cost of leak repair is also not included. Since leaks are continually discovered and repaired in the normal course of operations, the leaks found in the leak detection program would be repaired eventually. If the leaks are repaired as part of a leak detection program, as is BAAP's policy, the utility avoids the expense of repairing them as they are accidentally discovered. Although some cost savings would be realized in fixing the leaks when they are discovered by a leak detection program, as opposed to accidentally, AWWA Manual 36 allows the auditor to assume that the savings is negligible.

- The total payback of the leak detection program was calculated by dividing the total cost of the leak detection program by the cost savings of recovering leakage. The total cost of the leak detection survey was taken from contractor's cost and from direction from AWWA. The cost of a leak detection survey was assumed to be $150 per mile of pipe surveyed.

Results: Table 3-4 summarizes the results of the water audit. The LCCA and water audit worksheets can be found in Appendix D.

Table 3-4. ECO #1 Economic Analysis

Amount of Recoverable Leakage (gal/yr)	116,733,825
Cost of Process Water (per 1000 gal)	$0.349
Total Cost of Leak Detection Program	$20,160
Annual Cost Savings	$40,740
Total Discounted Cost Savings	$524,574
Simple Payback (years)	0.49
Savings-to-Investment Ratio	30.34

ECIP funding qualifications require an ECO candidate to have a simple payback of 10 years or less and a savings-to-investment ratio (SIR) of 1.25 or better. This ECO meets government funding criteria.

3.3.2 ECO #2: Reline Designated Sections of Piping in Poor Condition

Proposed Modifications: BAAP personnel have identified four sections of piping that are in worse condition than other piping and have been repaired on numerous occasions. The pipes in those four sections would be cleaned and lined with cement in order to repair current leaks as well as to prevent potential future leaks from occurring. The method of pipe lining was chosen over pipe replacement because it is less expensive and would produce a higher economic savings. Cost estimates comparing the costs of rehabilitation versus replacement of the designated piping can be found in Appendix D.

Existing Conditions: The piping designated by BAAP personnel as having a high incidence of repair are 14 inch and 24 inch diameter steel pipe installed in the 1940s. The ECO evaluation does not apply to service branches, only to the main lines that BAAP identified. The specific sections of piping are:

- 24 inch diameter pipe that runs along coordinate East 2,023. This section starts at Valve #368 to the north and ends at Valve #F-9 to the south. The pipe has a total length of 2,644 feet and supplies 10 service branches.

- 24 inch diameter pipe that runs along coordinate East 3,013. This section starts at Valve #281 to the north and ends at Valve #F-11 to the south. The pipe has a total length of 2,244 feet and supplies 12 service branches.

- 14 inch diameter pipe that runs along coordinate East 4,885. This section is limited by Valve #268 to the north and Valve #341 to the south. The pipe has a total length of 2,870 feet and supplies 38 service branches.

- 14-inch diameter pipe that runs along coordinate East 4,215. The section starts at Valve #204 to the north and ends at Valve #242 to the south. The pipe has a total length of 2,440 feet and supplies 22 branches.

The grand total of pipe to be relined is 4,890 feet of 24 inch diameter steel pipe and 5,310 feet of 14" diameter steel pipe.

Method of Analysis: Analysis proceeded as follows:

- A cost estimate was created to determine the cost of relining the designated piping. Costs for relining pipe per linear foot were taken from contractor bids for similar jobs at BAAP, from case studies of pipe rehabilitation of other water systems, and from Means Mechanical Cost Data.

- Current leakage in these particular pipes was identified. Quantities and location of leaks were based on the results of the leak detection survey.

- Potential leakage was predicted using the leakage density factor (see Section 3.1.3). Due to their condition, there is a strong probability that these pipes will continue to exhibit new leaks even after current leaks are repaired. Therefore, the assumption was made that a cost savings can be claimed in an LCCA for the repair of potential future leakage.

- A LCCA was completed to determine the life cycle cost of relining these particular pipes. Repairing the pipe by this relatively permanent method will not only stop current leakage, it will also serve to end any potential leakage. This will translate into maintenance and chemical treatment savings as well as energy savings.

Results: Table 3-5 summarizes the results of the economic analysis. The LCCA, cost estimates, and calculations of total leakage savings can be found in Appendix D.

Table 3-5. ECO #2 Economic Analysis

Total Investment Cost	$724,676
Annual Water Savings - Current Leakage (kgal/year)	51,100
Annual Water Savings - Potential Leakage (kgal/year)	3,536
Annual Energy Cost Savings	$2,568
Annual Non-Energy Cost Savings	$83,156
Total Discounted Cost Savings	$1,278,139
Simple Payback (years)	8.45
Savings-to-Investment Ratio	1.76

Relining the designated pipes meets government funding criteria.

3.3.3 ECO #3: Isolate Piping in "Caretaker" Areas

Proposed Modifications: "Caretaker" areas are designated by BAAP as including those buildings that no longer require fire protection. If the process water piping lines that serve these areas are capped, current and future leakage in those areas are eliminated. The result would be significant energy, maintenance, and chemical treatment savings.

Existing Conditions: BAAP has designated buildings in eighteen different areas as having "Caretaker" status. However, only six areas consist of enough "Caretaker" buildings to the extent that fire protection can be completely shut off. Each of the following areas was evaluated as a separate ECO:

- **ECO #3A.** Area #8 (E-Line NC)

- **ECO #3B.** Area #1 (Old Acid Area)
- **ECO #3C.** Area #12 (West Section of D-Line SB)
- **ECO #3D.** Area #13 (West Section of E-Line SB)
- **ECO #3E.** Area #9 (F-Line NC)
- **ECO #3F.** Area #18 (Rocket East)

Method of Analysis: Analysis proceeded as follows:

- Buildings classified by BAAP as having "Caretaker" status were located on site maps. Areas containing "Caretaker" buildings exclusively were specified. The lines that will disconnect those areas from the process water system were identified.

- The length of each diameter of pipe serving each "Caretaker" area was approximately determined from site maps of BAAP. Future leakage in each "Caretaker" area was predicted by multiplying the lengths of each diameter of pipe by the leakage density factor (see Section 3.1.3).

- A cost estimate was constructed to determine the cost of isolating each specific area from the process water system. Isolating the area will involve excavating and capping off the piping. The pipe will be capped near a main line valve, which will be used to isolate the flow. Capping the pipe as opposed to closing a valve was chosen for two reasons. First, capping the pipe is a more permanent means of isolating piping in "Caretaker" area. Valves could be accidentally opened in the future which would negate any potential leakage savings claimed by this ECO. Second, capping the line would eliminate any future leakage that might occur through a closed main line valve.

- A LCCA was completed to determine the life cycle cost of isolating each "Caretaker" area. Energy, maintenance and chemical treatment savings were calculated for current and future leaks in each area.

Results: Table 3-6 summarizes the economic analyses. The LCCA, cost estimates, and calculations of piping lengths and leakage saved can be found in Appendix D.

Table 3-6. ECO #3 Economic Analysis

	ECO #3	ECO #3A	ECO #3B	ECO #3C	ECO #3D	ECO #3E	ECO #3F
"Caretaker" Area	-	8	1	12	13	9	18
Total Investment Cost	$71,403	$13,654	$8,326	$5,351	$13,676	$13,589	$16,807
Annual Water Savings (kgal/year)	18,732	2,752	1,001	3,127	1,203	1,456	9,195
Annual Energy Cost Savings	$880	$129	$47	$147	$57	$68	$432
Annual Non-Energy Cost Savings	$28,510	$4,188	$1,523	$4,759	$1,831	$2,216	$13,994
Total Net Discounted Savings	$438,211	$64,374	$23,411	$73,152	$28,143	$34,061	$215,094
Simple Payback (yrs)	2.43	3.16	5.30	1.09	7.25	5.95	1.17
SIR	6.14	4.71	2.81	13.67	2.06	2.51	12.80

All ECOs in this section display favorable payback results. Note that the feasibility of this ECO is largely due to significant maintenance savings, as well as potential leakage savings.

If buildings are taken off "Caretaker" status in the future, fire protection must be restored to those buildings. It is also recommended that pipe lines that are capped off remain accessible in the future for this reason.

3.3.4 Perform Leak Detection Program After Implementing ECOs #2 and #3

Proposed Modifications: The water audit and leak detection program analyzed in ECO #1 was found to produce favorable economic payback under the conditions of the current process water system. However, should the projects for ECOs #2 and #3 be implemented first, the amount of process water cost to leakage would be reduced. In addition, if the process water piping in "Caretaker" areas are capped off, the cost of the leak detection survey will be reduced because a lesser amount of pipe will be investigated.

Proposed Conditions: The total mount of water currently pumped into the process water system is 250,900,000 gallons per year according to historical meter data. Once ECO #2 is implemented (relining four sections of piping with cement), it is estimated that 54,636,000 gallons of water lost annually to leakage will be saved. It is also estimated that ECO #3 will isolate approximately 15 miles of piping and save 18,732,000 gallons of leakage annually. Therefore, the estimated amount of water pumped into the process water system after these projects are implemented is 177,532,000 gallons per year.

Water usage in the process water system is listed in Table 3-3. These values, other than leakage, will not change as a result of the implementation of ECOs #2 and #3.

A water audit was performed on the process water system, according to guidelines set by AWWA Manual 36, which displays the effects of implementing ECOs #2 and #3 on potential water system leakage. Table 3-7 summarizes the results of the water audit with the revised numbers.

Table 3-7 Water Audit Results

Process Water Uses	Gallons Per Year
Fire Hydrants	13,500,000
Industrial Uses	
Boilers	3,900,000
Cooling system	21,100,000
Domestic Uses	6,300,000
Maintenance Activities	2,500,000
Irrigation (cattle)	2,400,000
Discovered leakage	44,323,200
Reservoir evaporation	1,231,700
Total Identified Water Losses	**95,254,900**
Potential water system leakage	
Recoverable	61,707,825
Unrecoverable	20,569,275
Total Amount of Water Pumped	**177,532,000**

Method of Analysis: The method of analysis for ECO #4 is similar to ECO #1. The audit was performed according to guidelines set by AWWA Manual 36. All information on water usage, except leakage, was obtained from BAAP personnel.

The difference between the water audits of ECOs #1 and #4 is the timeframe that each is performed. ECO #1 is based on current meter data in the process water system. The total amount of water pumped was estimated at 250,900,000 gallons per year. The total amount of water pumped for ECO #4 is estimates the effects of implementing ECOs #2 and #3.

Once the four sections of pipe are rehabilitated (ECO #2), and the "Caretaker" areas are isolated (ECO #3), the amount of water pumped into the process water system will be reduced to approximately 177,532,000 gallons per year. The amount of potential water system leakage be reduced the total cost of the leak detection program will be reduced due to isolating the "Caretaker" areas. See Section 3.3.1 for more information on the method of analysis for a water audit and leak detection program.

Results: Table 3-8 summarizes the results of the water audit. The LCCA and water audit worksheets can be funded in Appendix D.

Table 3-8. ECO #4 Economic Analysis

Amount of Recoverable Leakage (gal/yr)	$61,707,825
Cost of Process Water (per 1000 gal)	$0.349
Total Cost of Leak Detection Program	$17,640
Annual Cost Savings	$21,536
Total Discounted Cost Savings	$323,356
Simple Payback (years)	0.82
Savings-to-Investment Ratio	18.33

Note that performing a water audit and leak detection survey displays extremely favorable payback even after leak prevention and pipe rehabilitation projects are implement Under AWWA guidelines a leak detection program should be performed at least every two years.

4. SUMMARY AND RECOMMENDATIONS

4.1 SUMMARY OF THE BAAP PROCESS WATER SYSTEM

According to the data accumulated from the field survey and the leak detection survey, the following were noted:

- The process water system uses an average of 250,900,000 gallons of water per year, which translates to a usage rate of almost 687,400 gallons per day.

- Although BAAP has not been production since 1975, an estimated 36,200,000 gallons per year (15%) are required for the necessary operation and maintenance of BAAP. The water is primarily used for fire protection, irrigation, and some industrial uses.

- Approximately 44,323,200 gal/yr (18%) of the total process water usage is the estimated value of leakage discovered and repaired during normal maintenance activities.

- The estimated value for recoverable leakage was calculated to be 116,733,825 gal/yr, or nearly 47% of the total usage.

- The estimated leakage found by the leak detection survey was 194,500 gpd (70,992,500 gal/yr), or just over 28% of the total usage.

- A leak detection survey conducted in 1990 identified 202,000 gpd leakage in the process water system.

The percentage of water lost to leakage is misleading because BAAP does not use any water for production. If BAAP was using process water for production, the amount of water lost to leakage would be considered acceptable. The Wells Engineers report estimated that 52,000,000 gpd of process water would be required to support Baseline Mobilization Production. The Full Mobilization Rate is 82,000,000 gpd. If the assumption was made that the recoverable leakage remained the same and the process water usage reached the Baseline Mobilization Rate, the percentage of leakage in the process water system would be approximately 3%. See Appendix C for detailed calculations.

Nonetheless, the water audit estimated a value of over 116 million gpd (almost 320,000 gpd) of process water that is recoverable leakage. This represents a significant potential for water savings, which would translate into energy and cost savings.

BAAP has already taken steps to reduce the amount of leakage in the process water system. BAAP has conducted three leak detection surveys in the last ten years. BAAP also has a full-time maintenance staff which has the sole responsibility of repairing discovered leaks.

Because of these efforts, the usage rate of the process water system has remained fairly constant. Under normal conditions for a system of this age, it can be expected that the leakage rate will continue to increase.

BAAP has also performed several past projects to reline water mains. It should be noted that BAAP has not experienced any problems with water mains that have rehabilitated.

BAAP is also implementing projects which will reduce the cost of pumping process water, thus decreasing the value of water lost to leakage. Pumping water from the IRM Facility with a 40 hp motor rather than pumping from groundwater wells using a 100 hp motor has been shown to save over $5,500 annually in pumping energy alone (see Appendix D for calculations).

4.2 SUMMARY OF ENERGY AUDIT

According to the Scope of Work, ECIP criteria is to be used to categorize ECOs. In order to qualify for government funding programs, the ECOs must have a simple payback of 10 years or less and a SIR of 1.25 or greater. For this study, four primary ECOs were investigated. Table 4-1 summarizes the ECOs investigated in this study.

Table 4-1. Summary of ECOs

ECO No.	Description	Investment Cost	Annual Water Savings*	SIR	Payback (yrs)
1	Implement Leak Detection	$ 20,160	116.73	30.34	0.49
2	Reline Design. Main Lines	724,676	54.64	1.76	8.45
3	Isolate "Caretaker" Areas	71,403	18.73	6.14	2.43
3A	Isolate Area #8	13,654	2.75	4.71	3.16
3B	Isolate Area #1	8,324	1.00	2.81	5.30
3C	Isolate Area #12	5,321	3.13	13.67	1.09
3D	Isolate Area #13	13,676	1.20	2.06	7.25
3E	Isolate Area #9	13,589	1.46	2.51	5.95
3F	Isolate Area #18	16,807	9.20	12.80	1.17
4	Leak Detection After #2,#3	17,640	61.71	18.33	0.82

*Annual Water Savings are in units of millions of gallons saved per year.

4.3 RECOMMENDATIONS

It is recommended that ECOs that qualify for government funding programs be implemented. Specifically for the following ECOs:

- **ECO #1.** According to the guidelines set by AWWA Manual 36, a leak detection survey should be performed every two years. Currently, BAAP has performed a

leak detection survey at a frequency of every five years. Because of this program and the efforts of a maintenance crew that repairs discovered leaks, the amount of leakage has remained fairly constant over the last 10 years. A more aggressive leak detection program, which would include a water audit, should produce a decrease in the amount of leakage. The water audit showed that the benefits of performing a leak detection survey and repairing the leaks that are discovered during the survey (which is BAAP's policy) will outweigh the costs of the survey, up to a two-year frequency.

- **ECO #2.** Another benefit of an aggressive leak detection program is that specific areas that require rehabilitation will be identified more quickly. Relining existing piping has been shown to be an economically feasible means of extending the life of older water mains. Not only does it serve to eliminate current leakage, it also eliminates the need for future maintenance, which is a significant savings. The four areas identified in this ECO should be rehabilitated.

- **ECO #3.** Isolating "Caretaker" areas becomes economically feasible once future energy and maintenance savings are included. The ECO probably would not have favorable economics based strictly on actual current leakage savings. In fact, two of these "Caretaker" areas do not currently have any identified leaks. If this ECO is implemented, special care must be taken that the buildings in these areas remain in "Caretaker" status. If, in the future, buildings are taken off "Caretaker" status, fire protection must be restored to those buildings. It is also recommended that valves that are capped off be accessible in the future for this reason.

- **ECO #4.** If ECOs #2 and #3 are implemented before a water audit can be performed, the values for the total amount of process water pumped and the cost of the leak detection program will still produce a favorable economic payback. A water audit and leak detection program is recommended at least every two years.

Programming documentation was prepared for each ECO (see Appendix E). It is important to note that the documentation and recommendations for ECO #1 and #4 are identical except that ECO #1 is based on current process water conditions. ECO #4 is based on the estimated condition of the process water system after ECOs #2 and #3 are implemented. BAAP should determine the appropriate time to submit either ECO #1 or #4 for government funding. Depending upon the timeframe for project funding and implementation, it may not be appropriate to submit both.

5. REFERENCES

AWWA Manual 36, Water Audits and Leak Detection, American Water Works Association, Denver, CO, 1990.

AWWA Research Foundation, Assessment of Existing and Development of Water Main Rehabilitation Practices, American Water Works Association, Denver, CO, 1990.

AWWA Research Foundation, Water Main Evaluation for Rehabilitation/Replacement, American Water Works Association, Denver, CO, 1986.

AWWA Research Foundation, Control of Water Quality Deterioration Caused by Corrosion of Cement-Motor Pipe Lining, American Water Works Association, Denver, CO, 1991.

NOAA Technical Report NWS 33, Evaporation Atlas for the Contiguous 48 United States, National Oceanographic and Atmospheric Association, Washington, DC, June 1982.

NOAA Technical Report NWS 34, Mean Monthly, Seasonal, and Annual Pan Evaporation for the United States, National Oceanographic and Atmospheric Association, Washington, DC, June 1982.

Olin Corporation Defense Systems Group, Report on Pitometer Water Waste Survey, Badger army Ammunition Plant, Baraboo, WI, The Pitometer Associates, Montclair, NJ, 1990.

Olin Corporation Defense Systems Group, Badger Army Ammunition Plant Water System Analysis, Baraboo, Wisconsin, 65% Report, Wells Engineers, Inc., Omaha, NE, June 1989.

Walski, Thomas M., Ph.D., P.E., Analysis of Water Distribution Systems, Van Nostrand Reinhold Company Inc., 1984.

APPENDIX A

SCOPE OF WORK AND CONFIRMATION NOTICES

Scope of Work
Confirmation Notices
BAAP Mission Statement

June 1994
Revised Sep 1994 (1)

APPENDIX "A"

CONTRACT NO. DACA01-94-D-0033
DELIVERY ORDER NO. 0004

GENERAL SCOPE OF WORK

FOR A

WATER CONSERVATION STUDY

AT

BADGER ARMY AMMUNITION PLANT

Performed as part of the

ENERGY ENGINEERING ANALYSIS PROGRAM (EEAP)

1.1 Perform a site survey of the Process Water System to collect all data required to evaluate the specific energy conservation opportunities (ECOs) included in this study.

1.2 Evaluate specific ECOs to determine their energy savings potential and economic feasibility.

1.3 Provide project documentation for recommended ECOs as detailed herein.

1.4 Prepare a comprehensive report to document all work performed, the results and all recommendations.

2. <u>GENERAL</u>

2.1 This study is limited to the evaluation of the Process Water System ECOs listed in Annex A, DETAILED SCOPE OF WORK.

2.2 The information and analysis outlined herein are considered to be minimum requirements for adequate performance of this study.

2.3 For the Process Water System ECOs listed in Annex A, all methods of energy conservation which are reasonable and practical shall be considered, including improvements of operational methods and procedures as well as the physical facilities. All energy conservation opportunities which produce energy or dollar savings shall be documented in this report. Any energy conservation opportunity considered infeasible shall also be documented in the report with reasons for elimination.

2.4 The study shall consider the use of all energy sources applicable to each system and ECOs.

2.5 The "Energy Conservation Investment Program (ECIP) Guid-
ance", described in letter from DAIM-FDF-U, dated 10 Jan 1994 and (1)
the latest revision from DAIM-FDF-U establishes criteria for ECIP (1)
projects and shall be used for performing the economic analyses of <u>all</u> ECOs and projects. The program, Life Cycle Cost In Design (LCCID), has been developed for performing life cycle cost calculations in accordance with ECIP guidelines and is referenced in the ECIP Guidance. If any program other than LCCID is proposed for life cycle cost analysis, it must use the mode of calculation specified in the ECIP Guidance. The output must be in the format of the ECIP LCCA summary sheet, and it must be submitted for approval to the Contracting Officer.

2.6 Energy conservation opportunities determined to be technically and economically feasible shall be developed into projects acceptable to installation personnel. This may involve combining

similar ECOs into larger packages which will qualify for ECIP, MCA, or PCIP funding, and determining in coordination with installation personnel the appropriate packaging and implementation approach for all feasible ECOs.

2.6.1 Projects which qualify for ECIP funding shall be identified, separately listed, and prioritized by the Savings to Investment Ratio (SIR).

2.6.2 All feasible non-ECIP projects shall be ranked in order of highest to lowest SIR.

2.6.3 At some installations Energy Conservation and Management (ECAM) funding will be used instead of ECIP funding. The criteria for each program is the same. The Director of Engineering and Housing will indicate which program is used at this installation. This Scope of Work mentions only ECIP, however, ECAM is also meant.

3. PROJECT MANAGEMENT

3.1 Project Managers. The AE shall designate a project manager to serve as a point of contact and liaison for work required under this contract. Upon award of this contract, the individual shall be immediately designated in writing. The AE's designated project manager shall be approved by the Contracting Officer prior to commencement of work. This designated individual shall be responsible for coordination of work required under this contract. The technical manager to serve as the Government's point of contact and liaison for all technical work required under this contract is Mr. Stan Owens (refer to Annex D for address). Mr. Daniel L. Sommer (office symbol CEMRO-ED-M) is the contrating officer's representative (COR) for this contract.

3.2 Installation Assistance. The Commanding Officer or authorized representative at the installation will designate an individual to assist the AE in obtaining information and establishing contacts necessary to accomplish the work required under this contract. This individual will be the installation representative.

3.3 Public Disclosures. The AE shall make no public announcements or disclosures relative to information contained or developed in this contract, except as authorized by the Contracting Officer.

3.4 Meetings. Meetings will be scheduled whenever requested by the AE or the Contracting Officer for the resolution of questions or problems encountered in the performance of the work. The AE's project manager and the Government's representative shall be required to attend and participate in all meetings pertinent to the work required under this contract as directed by the Contracting Officer. These meetings, if necessary, are in addition to the

presentation and review conferences.

3.5 Site Visits, Inspections, and Investigations. The AE shall visit and inspect/investigate the site of the project as necessary and required during the preparation and accomplishment of the work.

3.6 Records

3.6.1 The AE shall provide a record of all significant conferences, meetings, discussions, verbal directions, telephone conversations, etc., with Government representative(s) relative to this contract in which the AE and/or designated representative(s) thereof participated. These records shall be dated and shall identify the contract number, and modification number if applicable, participating personnel, subject discussed and conclusions reached. The AE shall forward to the Contracting Officer within ten calendar days, a reproducible copy of the records.

3.6.2 The AE shall provide a record of requests for and/or receipt of Government-furnished material, data, documents, information, etc., which if not furnished in a timely manner, would significantly impair the normal progression of the work under this contract. The records shall be dated and shall identify the contract number and modification number, if applicable. The AE shall forward to the Contracting Officer within ten calendar days, a reproducible copy of the record of request or receipt of material.

3.7 Interviews. The AE and the Government's representative shall conduct entry and exit interviews with the Director of Engi neering and Housing before starting work at the installation and after completion of the field work. The Government's representative shall schedule the interviews at least one week in advance.

3.7.1 Entry. The entry interview shall describe the intended procedures for the survey and shall be conducted prior to commencing work at the facility. As a minimum, the interview shall cover the following points:

a. Schedules.

b. Names of energy analysts who will be conducting the site survey.

c. Proposed working hours.

d. Support requirements from the Director of Engineering and Housing.

3.7.2 Exit. The exit interview shall briefly describe the items surveyed and probable areas of energy conservation. The

interview shall also solicit input and advice from the Director of Engineering and Housing.

4. <u>SERVICES AND MATERIALS</u>. All services, materials (except those specifically enumerated to be furnished by the Government), plant, labor, supervision and travel necessary to perform the work and render the data required under this contract are included in the lump sum price of the contract.

5. <u>PROJECT DOCUMENTATION</u>. All energy conservation opportunities which the AE has considered shall be included in one of the following categories and presented in the report as such:

5.1 <u>ECIP Projects</u>. To qualify as an ECIP project, an ECO, or several ECOs which have been combined, must have a construction cost estimate greater than $300,000, a Savings to Investment Ratio greater than 1.25 and a simple payback period of less than ten (1)
years. For ECAM projects, the $300,000 limitation may not apply; in such cases, the AE shall check with the installation for guidance. The overall project and each discrete part of the project shall have an SIR greater than one. All projects meeting the above criteria shall be arranged as specified in paragraph 2.6.1 (1)
and shall be provided with programming documentation. Programming documentation shall consist of a DD Form 1391, life cycle cost analysis (LCCA) summary sheet(s) (with necessary backup data to verify the numbers presented), and a Project Development Brochure (PDB). A life cycle cost analysis summary sheet shall be developed for each ECO and for the overall project when more than one ECO are combined. The energy savings for projects consisting of multiple ECOs must take into account the synergistic effects of the individual ECOs.

5.2 <u>Non-ECIP Projects</u>. Projects which do not meet ECIP criteria with regard to cost estimate or payback period, but which have an SIR greater than 1.25 shall be documented. Projects or ECOs in (1)
this category shall be arranged as specified in paragraph 2.6.2 (1)
and shall be provided with the following documentation: the life cycle cost analysis (LCCA) summary sheet completely filled out, a description of the work to be accomplished, backup data for the LCCA, ie, energy savings calculations and cost estimate(s), and the simple payback period. The energy savings for projects consisting of multiple ECOs must take into account the synergistic effects of the individual ECOs. In addition these projects shall have the necessary documentation prepared, as required by the Installation's representative, for one of the following categories:

a. O & M Energy Projects: An O & M Energy project is one that (1)
results in needed maintenance or repair to an existing facility, or (1)
replaces a failed or failing existing facility, and also results in (1)
energy savings. The criteria are similar to the criteria for ECIP (1)

projects, i.e., $300,000 construction cost, SIR _ 1.25, and simple (1)
payback period of less than ten years. In addition, if the project (1)
would replace a system or equipment that is considered "failed or (1)
failing" due solely to obsolete technology or inefficiency, the (1)
equipment to be replaced must have been in use for at least three (1)
years; and the simple payback period must be three years or less. (1)
(1)

(1)
b. Low Cost/No Cost Projects. These are projects which the (1)
Director of Engineering and Housing (DEH) can perform using his resources. Documentation shall be as required by the DEH.

5.3 Nonfeasible ECOs. All ECOs which the AE has considered but which are not feasible, shall be documented in the report with reasons and justifications showing why they were rejected.

6. DETAILED SCOPE OF WORK. The Detailed Scope of Work is contained in Annex A.

7. WORK TO BE ACCOMPLISHED.

7.1 Perform a Site Survey. The AE shall obtain all necessary data to evaluate the ECOs or projects by conducting a site survey. However, the AE is encouraged to use any data that may have been documented in a previous study. The AE shall document his site survey on forms developed for the survey, or standard forms, and submit these completed forms as part of the report. All test and/or measurement equipment shall be properly calibrated prior to its use.

7.2 Evaluate Selected ECOs. The AE shall analyze the ECOs mentioned in Annex A. These ECOs shall be analyzed in detail to determine their feasibility. Savings to Investment Ratios (SIRs) shall be determined using current ECIP guidance. The AE shall provide all data and calculations needed to support the recommended ECO. All assumptions and engineering equations shall be clearly stated. Calculations shall be prepared showing how all numbers in the ECO were figured. Calculations shall be an orderly step-by-step progression from the first assumption to the final number. Descriptions of the products, manufacturers catalog cuts, pertinent drawings and sketches shall also be included. A life cycle cost analysis summary sheet shall be prepared for each ECO

and included as part of the supporting data.

7.3 Combine ECOs Into Recommended Projects. During the Interim Review Conference, as outlined in paragraph [7.4.1], the AE will be advised of the DEH's preferred packaging of recommended ECOs into projects for implementation. Some projects may be a combination of several ECOs, and others may contain only one. These projects will be evaluated and arranged as outlined in paragraphs 5.1, 5.2, and 5.3. Energy savings calculations shall take into account the synergistic effects of multiple ECOs within a project and the effects of one project upon another. The results of this effort will be reported in the Final Submittal per par [7.4.2].

7.4 Submittals, Presentations and Reviews. The work accomplished shall be fully documented by a comprehensive report. The report shall have a table of contents and shall be indexed. Tabs and dividers shall clearly and distinctly divide sections, subsections, and appendices. All pages shall be numbered. Names of the persons primarily responsible for the project shall be included. The AE shall give a formal presentation of the interim submittal to installation, command, and other Government personnel. Slides or view graphs showing the results of the study to date may be used during the presentation. During the presentation, the personnel in attendance shall be given ample opportunity to ask questions and discuss any changes deemed necessary to the study. A review conference will be conducted the same day, following the presentation. Each comment presented at the review conference will be discussed and resolved or action items assigned. It is anticipated that the presentation and review conference will require approximately one working day. The presentation and review conference will be at the installation on the date agreeable to the Director of Engineering and Housing, the AE and the Government's representative. The Contracting Officer may require a resubmittal of any document(s), if such document(s) are not approved because they are determined by the Contracting Officer to be inadequate for the intended purpose.

7.4.1 Interim Submittal. An interim report shall be submitted for review after the field survey has been completed and an analysis has been performed on all of the ECOs. The report shall indicate the work which has been accomplished to date, illustrate the methods and justifications of the approaches taken and contain a plan of the work remaining to complete the study. Calculations showing energy and dollar savings, SIR, and simple payback period of all the ECOs shall be included. The results of the ECO analyses shall be summarized by lists as follows:

a. All ECOs eliminated from consideration shall be grouped into one listing with reasons for their elimination as discussed in par 5.3.

b. All ECOs which were analyzed shall be grouped into two list

ings, recommended and non-recommended, each arranged in order of descending SIR. These lists may be subdivided by building or area as appropriate for the study.

The AE shall submit the Scope of Work and any modifications to the Scope of Work as an appendix to the report. A narrative summary describing the work and results to date shall be a part of this submittal. At the Interim Submittal and Review Conference, the Government's and AE's representatives shall coordinate with the Director of Engineering and Housing to provide the AE with direction for packaging or combining ECOs for programming purposes and also indicate the fiscal year for which the programming or implementation documentation shall be prepared. The survey forms completed during this audit shall be submitted with this report. The survey forms only may be submitted in final form with this submittal. They should be clearly marked at the time of submission that they are to be retained. They shall be bound in a standard three-ring binder which will allow repeated disassembly and reassembly of the material contained within.

7.4.2 Final Submittal. The AE shall prepare and submit the final report when all sections of the report are 100% complete and all comments from the interim submittal have been resolved. The AE shall submit the Scope of Work for the study and any modifications to the Scope of Work as an appendix to the submittal. The report shall contain a narrative summary of conclusions and recommendations, together with all raw and supporting data, methods used, and sources of information. The report shall integrate all aspects of the study. The recommended projects, as determined in accordance with paragraph 5, shall be presented in order of priority by SIR. The lists of ECOs specified in paragraph [7.6.1] shall also be included for continuity. The final report and all appendices shall be bound in standard three-ring binders which will allow repeated disassembly and reassembly. The final report shall be arranged to include:

a. An Executive Summary to give a brief overview of what was accomplished and the results of this study using graphs, tables and charts as much as possible (See Annex B for minimum requirements).

b. The narrative report describing the problem to be studied, the approach to be used, and the results of this study.

c. Documentation for the recommended projects (includes LCCA Summary Sheets).

d. Appendices to include as a minimum:

1) Energy cost development and backup data

2) Detailed calculations

3) Cost estimates

4) Computer printouts (where applicable)

5) Scope of Work

ANNEX A

DETAILED SCOPE OF WORK

FOR

WATER CONSERVATION STUDY

BADGER ARMY AMMUNITION PLANT (BAAP)

1. This Annex contains the detailed Scope of Work for this energy study. The study shall be accomplished in accordance with the General Scope of Work and Annexes A, B, C, D, and E.

2. Requirements.

2.1 This study requires a thorough survey of the process water system using state-of-the-art underground leak detection equipment on all piping 6 inch and larger at BAAP. Refer to Annex E for the detailed requirements of the leak detection survey.

2.2 Process water system maps for BAAP shall be developed which will show the location and estimated flow of the leaks. The resulting maps will be compared with BAAP's current mission, and a decision will be made by BAAP whether to repair, replace or isolate faulty piping sections. The AE shall confer with BAAP personnel and agree upon projects to develop for the water piping upgrades. The energy savings resulting from these projects will include the reduced pumping costs, water treatment costs, annual repair costs where piping is replaced or isolated, and any other savings resulting from reduced water consumption.

3. Government Furnished Data. The following data and criteria is furnished for guidance and information.

a. One (1) set of full size drawings of the Process Water system at BAAP.

b. Architectural and Engineering Instructions, Design Criteria, dated 9 December 1991, Revised 8 July 1992.

c. TM5-785 Engineering Weather Data, pages: cover, IV, V, 3-416, 3-417, and 5-18.

d. AR5-4, Change No. 1, dated 1 August 1982 Department of the Army Productivity Improvement Program.

e. Energy Conservation Investment Program (ECIP) Guidance, dated 10 January 1994.

f. AR415-15, 1 January 1984, Military Construction, Army (MCA) Program Development.

g. Tri-Service Military Construction Program (MCP) Index, dated February 1991 for Cost Estimating.

4. <u>Life Cycle Costing Computer Program</u>. A computer program titled Life Cycle Costing in Design (LCCID) is available from the BLAST Support Office in Urbana, Illinois for a nominal fee. This computer program can be used for performing the economic calculations for ECIP and non-ECIP ECOs. The AE is encouraged to obtain and use this computer program. The BLAST Support Office can be contacted at 144 Mechanical Engineering Building, 1206 West Green Street, Urbana, Illinois 61801. The telephone number is (217)333-3977 or (800)842-5278.

5. <u>Project Coordinator at the Installation.</u> The Badger Army Ammunition Plant coordinator for this study is Mr. Don Hartmann, phone (608) 356-5525, extension 328. His address is shown in Annex D.

6. <u>Copies of Report Required</u>. The number of copies for each addressee shall be as shown in Annex D. All copies shall be sent directly to the addresses as shown in Annex D.

7. <u>Schedule for Study</u>.

	Calendar Days From Notice To Proceed
a. Interim Submittal:	150 days
b. Government's Review:	180 days
c. Presentation & Review Conference:	190 days
d. Final Submittal:	220 days
e. Government Review:	250 days
f. Final Submittal Corrected:	270 days

8. <u>Scheduling and Reporting Progress</u>. The Contractor shall prepare and submit an activity diagram or schedule, which will indicate individual activities, significant events and milestones along with schedule dates. The schedule shall cover the entire scope and work period of the contract. In addition, the Contractor shall submit monthly reports of progress. These reports shall be in letter and chart form and should be worded or keyed to indicate progress on the activity diagram and shall describe work accomplished in the immediate past and work to be done in the immediate future. Monthly reports shall be sent to the addressees numbered 6 and 7 as shown in Annex D.

ANNEX B

EXECUTIVE SUMMARY GUIDELINE

1. Introduction.

2. Building Data (types, number of similar buildings, sizes, etc.)

3. Present Energy Consumption of Buildings or Systems Studied.

   o Total Annual Energy Used.

   o Source Energy Consumption.

     Electricity - KWH, Dollars, BTU
     Fuel Oil - GALS, Dollars, BTU
     Natural Gas - THERMS, Dollars, BTU
     Propane - GALS, Dollars, BTU
     Other - QTY, Dollars, BTU

   o Present process water consumption - Millions of Gallons per year (1 (1

4. Re-evaluated Projects Results.

5. Energy Conservation Analysis.

   o ECOs Investigated.

   o ECOs Recommended.

   o ECOs Rejected. (Provide economics or reasons)

   o ECIP Projects Developed. (Provide list)*

   o Non-ECIP Projects Developed. (Provide list)*

   o Operational or Policy Change Recommendations.

* Include the following data from the life cycle cost analysis summary sheet: the cost (construction plus SIOH), the annual energy savings (type and amount), the annual dollar savings, the SIR, the simple payback period and the analysis date.

6. Energy and Cost Savings.

   o Total Potential Energy and Cost Savings.

   o Percentage of Energy Conserved.

   o Energy Use and Cost Before and After the Energy Conservation Opportunities are Implemented.

   o Annual water saving in millions of gallons per year. (1

ANNEX C

(18) ✓

REQUIRED DD FORM 1391 DATA

To facilitate ECIP project approval, the following supplemental data shall be provided:

a. In title block clearly identify projects as "ECIP."

b. Complete description of each item of work to be accomplished including quantity, square footage, etc.

c. A comprehensive list of buildings, zones, or areas including building numbers, square foot floor area, designated temporary or permanent, and usage (administration, patient treatment, etc.).

d. List references, and assumptions, and provide calculations to support dollar and energy savings, and indicate any added costs.

(1) If a specific building, zone, or area is used for sample calculations, identify building, zone or area, category, orientation, square footage, floor area, window and wall area for each exposure.

(2) Identify weather data source.

(3) Identify infiltration assumptions before and after improvements.

(4) Include source of expertise and demonstrate savings claimed. Identify any special or critical environmental conditions such as pressure relationships, exhaust or outside air quantities, temperatures, humidity, etc.

e. Claims for boiler efficiency improvements must identify data to support present properly adjusted boiler operation and future expected efficiency. If full replacement of boilers is indicated, explain rejection of alternatives such as replace burners, nonfunctioning controls, etc. Assessment of the complete existing installation is required to make accurate determinations of required retrofit actions.

f. Lighting retrofit projects must identify number and type of fixtures, and wattage of each fixture being deleted and installed. New lighting shall be only of the level to meet current criteria. Lamp changes in existing fixtures is not considered an ECIP type project.

g. An ECIP life cycle cost analysis summary sheet as shown in the ECIP Guidance shall be provided for the complete project and for each discrete part included in the project. The SIR is applicable to all segments of the project. Supporting documentation consisting of basic engineering and economic calculations showing how savings were determined shall be included.

h. The DD Form 1391 face sheet shall include, for the complete project, the annual dollar and MBTU savings, SIR, simple amortization period and a statement attesting that all buildings and retrofit actions will be in active use throughout the amortization period.

i. The calendar year in which the cost was calculated shall be clearly shown on the DD Form 1391.

j. For each temporary building included in a project, separate documentation is required showing (1) a minimum 10-year continuing need, based on the installation's annual real property utilization survey, for active building retention after retrofit, (2) the specific retrofit action applicable and (3) an economic analysis supporting the specific retrofit.

k. Nonappropriated funded facilities will not be included in an ECIP project without an accompanying statement certifying that utility costs are not reimbursable.

l. Any requirements required by ECIP guidance dated 4 Nov 1992 and any revisions thereto. Note that unescalated costs/savings are to be used in the economic analyses.

m. The five digit category number for all ECIP projects except for Family Housing is 80000. The category code number for Family Housing projects is 71100.

ANNEX D
Distribution Address List for Report

1. Commander
U.S. Army Engineer District, Mobile
ATTN: CESAM-EN-CC (T. Battaglia)
P.O. Box 2288
Mobile, AL 36628-0001
1 Copy of Corrected Final

2. HQDA, ODCSLOG
ATTN: DALO-TSE (Jim Paton)
Pentagon
Washington, D.C. 20310-0561
1 Copy of Executive Summary

3. Commander
U.S. Army Corps of Engineers
ATTN: CEMP-ET (D. Gentil)
20 Massachusetts Avenue, NW
Washington, D.C. 20314-1000
1 Copy of Executive Summary

4. Commander
U.S. AMC Installation & Service Activity
ATTN: AMXEN-C (John Nache)
Rock Island, IL 61299-7190
1 Copy

5. Commander
U.S. Army Engineer Division, Missouri River
ATTN: CEMRD-MO-MA (J. Whelchel)
12565 West Center Road
Omaha, NE 68144-3869
1 Copy

6. Commander
U.S. Army Engineer District, Omaha
ATTN: CEMRO-ED-MC (S. Owens)
215 North 17th Street
Omaha, NE 68102-4978
3 Copies

7. Commander's Representative
Badger Army Ammunition Plant
ATTN: SMCBA-OR-(D. Hartmann)
Baraboo, WI 53913
3 Copies

(19) ✓

ANNEX E
SCOPE OF WORK
FOR
SONAR LEAK DETECTION
IN SUPPORT OF
WATER CONSERVATION STUDY
BADGER ARMY AMMUNITION PLANT (BAAP)

1.0 PURPOSE OF WORK. The consultant shall provide all personnel, equipment, tools, materials, supervision and other items and services necessary to perform a sonar leak detection survey of the process water system at the Badger Army Ammunition Plant (BAAP). The work shall include all process water lines 6 inches and larger as shown on the Government furnished set of drawings.

2.0 NORMAL HOURS: Normal duty hours at BAAP are 7:00 a.m. to 5:30 p.m., Monday through Thursday, except federal holidays.

3.0 REQUIREMENTS OF WORK.

3.1 Prioritize the Survey Area. The consultant is to establish a logical survey priority scheme based on dividing the distribution system into sub-areas and zones, in order to address the areas of highest suspected leakage first and the areas of lowest suspected leakage last. The zones shall be established to sub-divide the system into zones of equivalent size to approximately one week of survey. Initial zone survey priorities shall be established based upon known system information (pressures, surfacing leaks, pipe materials, soil compositions, etc.) The consultant will establish a permanent, ongoing survey documentation so that resurvey intervals can be considered in the future.

3.2 Surveying and Pinpointing. The following four tiered approach shall be used in pinpointing leaks.

(a) Appurtenance Acoustic Survey-Correlator Pinpointing. Primary sounding points for appurtenance leak surveys are all accessible main line gate valves, fire hydrants and designated service connections. When leaking valves/fire hydrants are encountered, or when indicated fittings cannot be accessed, alternative sounding points (e.g. services) must be located and used. Such alternative points shall be within 15 - 75 feet of the leaking appurtenances. When these conditions can not be met, ground surface soundings shall be taken at six inch intervals for hard cover surfaces (pavement, concrete, etc.). For soft cover surfaces, probe rods shall be used and inserted to minimum depths of at least six inches and horizontal intervals of 10 inches. Every attempt will be made to localize suspected leak sites and mark for excavation. For pinpointing of all non-visible leaks, the primary method will be by acoustic leak correlator without drill holes or excavations. Subsequently, pinpointing by surface sounding or assisted direct contact through probe holes or excavations may be utilized.

(b) Advanced Survey Correlator Pinpointing. When the guidelines outlines in section a cannot be met, the following methodology shall be used.

1. When appurtenance spacing is greater than specified and/or when excessive noise or other conditions interfere with the effectiveness of the acoustic survey methods, or the plastic pipe, statistical noise analyzers will be temporarily installed for unmanned acoustic soundings during nighttime hours.

2. For at least 15 percent of the distribution system by the methods specified in section a and where no main leaks are identified, the statistical noise analyzers shall be deployed randomly for verification of no leak conditions.

(c) Sub-district Step Testing Flow Measurements-Correlator Pinpointing. As an alternative to the above methods and where pitometric zones are already established, sub-district step testing flow measurements will be performed using a radiotelemetric step testing system and dataloggers.

3.3. Documentation. The consultant shall document the survey work with monthly reports. The reports shall include:

(a) A summary showing time required for surveying (sounding), leak pinpointing (correlating) and other tasks, daily miles of pipe surveyed, approximate water losses [gallons per day (GPD)] discovered, types and quantities of leaks found as well as any appropriate recommendations for improvements to the distribution systems. Water losses will only be estimates based on the experience and judgment of the leak detection company.

(b) Daily survey reports indicating areas covered, number and type of contact points utilized and observations of any water system irregularities found.

(c) Individual leak reports with drawings for each leak location determined, type of leak found, type of ground cover and how pinpointed.

A final leak detection survey report shall be prepared to describe the investigation and define the results. The final report shall include a review of the survey procedure and methodology. The report shall identify major and minor problem areas, if any, as well as indicate the locations of such problems. The report shall also make recommendations for future leak detection surveys and describe methods for accomplishing this type program.

3.4. Quality Assurance/Quality Control. The consultant shall submit a QA/QC project plan, before work begins, which will minimize testing problems and maximize data validity.

3.5. Review and Coordination. Representatives of the Contracting Officer will review the progress and technical adequacy of the work at 90% (prefinal) completion. The consultant shall submit two (2) sets of draft reports. Such review will not relieve the contractor from performing all contract requirements, except as may be waived in writing by the Contracting Officer. Written comments will be provided to the consultant by the Contracting Officer for incorporation into the final report. Meetings are not anticipated, but may be necessary prior to the final submittal to work out details of the reports. These meeting shall be coordinated at mutually agreed times and locations.

3.6 Schedule of Work. Work is to commence immediately upon notice to proceed. The following schedule should be adhered to for Annex E work only. Refer to Annex A, page A-2, for the schedule for the entire study.

Table 3.1
SUBMITTALS AND SCHEDULE
NUMBER OF COPIES

Item	Para	Date Due	Omaha District	Badger AAP
Quality Assurance Plan	3.4	With Proposal	1	1
Prefinal Report (90%)	3.3	60 Days from NTP	1	1
Final Report	3.3	90 Days from NTP	2	2

1. Commander
   U.S. Army Corps of Engineers
   Omaha District
   Attn: CEMRO-ED-MC
   215 North 17th Street
   Omaha, NE 68102-4978

2. Commander's Representative
   Badger Army Ammunition Plant
   Attn: SMCBA-OR (D. Hartmann)
   Baraboo, WI 53913-5000

4.0 RELEASE OF INFORMATION. The information developed, gathered and assembled in fulfillment of the contract requirements, as defined in or related to the Scope of Work, will not be released by the Consultant, his sub-contractors or their associates without prior coordination and approval by the Contracting Officer or designated representative. All immediate inquiries should be directed to the contracting officer.

5.0 USE OF INFORMATION. The information developed, gathered, assembled and reproduced by the consultant, his sub-contractors or their associates in fulfillment of the contract requirements, as defined or related to the Scope of Work, will become the complete property of the Government and will, therefore, not be used by the consultant for any purpose at any time without the written consent of the Contracting Officer.

Basis of Fee

Water Conservation Study
Badger Army Ammunition Plat (BAAP)
Baraboo, Wisconsin

This Basis of Fee has been prepared in accordance with the above titled Request for Proposal, dated June 1994, the revised scope of work (September 1994) and negotiating meetings of 9 September and 12 September 1994, to be performed as part of the Energy Engineering Analysis Program (EEAP).

Study

EMC, Inc. will conduct an underground leak detection study on all piping 6" and larger at BAAP. The leak detection survey will be performed by our subcontractor, M.E. Simpson Co. Inc., Valparaiso, Indiana. We will understand the extent of the piping system to be studied Is 117 miles. The study will include:

- A work Schedule;
- A kickoff meeting with site personnel to ascertain the problems with the BAAP water system and to get acquainted with BAAP;
- 2 Engineers on site to obtain waterline, pump and capacity data. Crew of 2 Technicians with appropriate equipment (transducers, ground microphones, correlator and other) to conduct the leak detection study;
- daily progress reports during the survey identifying leaks found and areas serviced;

Site Audit Report

We will write a site audit report which complies and presents the information acquired during the site visit. Comments from BAAP personnel regarding the waterline status and water line data will be incorporated into the report. The report will incorporate an estimate of the quantity of water lost due to the leaks found in the system, and a presentation of other energy/water saving opportunities.

The first version of the report will be presented at the interim submittal date. The second and final version of the report will be submitted at the final submittal date. We understand you may want to make a few corrections or clarifications to the final submittal.

The report will include an executive summary, the narrative section, and documentation including an ECO analysis, cut sheet/drawings, and LCCA

summary sheets(s). The report will also include a waterline map showing locations of leaks, a cost estimate and computer printouts, where applicable.

In addition to the report preparation, we will prepare the DD1391 form for your review.

We will submit monthly progress reports.

Meetings

We understand there will be one meeting at the interim review time period. We have made allowances for the Project Manager and the Project Engineers to attend the meeting. We are confident your questions will be answered by these two members of the team.

Schedule

Manager and the Project Engineers to attend the meeting. We are confident your questions will be answered by these two members of the team.

Schedule

We are secure with you project schedule as laid out in section 7 of Annex A with one stipulation. We ask the award of the contract be made prior to 7 October 1994 so the leak detection crew can complete their work prior to the middle of November.

We base this request upon anticipating the requirement of a full month to complete the leak detection testing. Based upon historical weather, for the best results and timely completion of the project, the crew should complete their work prior tot he middle of November.

Additional Assumptions

We based our proposal on making use of the services of one "helper" and backhoe, as required, from the BAAP maintenance staff during the leak detection portion of our study.

The map we provide to the BAAP will not meet the COE requirements as a master plan utility map.

DWG/jls(31)

EMC ENGINEERS, INC.

2750 South Wadsworth Blvd. • Suite C-200
Denver, Colorado 80227-3400
303/988-2951 • Fax: 303/985-2527

CONFIRMATION NOTICE

Confirmation Notice No. 1 EMC #1406.004

DATE: 20 December, 1994

DATE of PHONE CONVERSATION: 2 December 1994

FM: Michael Scholz
TO: Mr. Stan Owens
REPRESENTING: COE
PHONE NUMBER: 1-402-221-4523

PROJECT: BAAP Water Study
CONTRACT No.: DACA01-94-D-0033, DO 0004

NOTES PREPARED BY: Michael Scholz, E M C Engineers, Inc.

SUBJECT: BAAP Groundwater Remediation Project DACA45-94-C-0150 (Pump and Treat Project) and its effect on the BAAP Water Study

The following is a summary of the items discussed, the comments made, and the decisions made during the telephone conversation.

Mr. Scholz contacted Mr. Owens to discuss the aforementioned projects and how one impacts the other. EMC was made aware of a Pump and Treat Project scheduled for construction in the 6 months following October which will construct a 10 inch waterline from the pump and treat facility at BAAP to the process water system at BAAP. We were made aware of the project during a site investigation survey we were conducting for the Water Study.

EMC followed up the onsite interviews with additional telephone conversations with Mr. Dennis Thurow at BAAP and Ms. Liala Berre of Omaha COE. EMC confirmed the project is going to be constructed.

Mr. Owens indicated Ms. Berre had called him on 1 December to discuss the projects.

Among other things EMC was charged with determining ECOs which will reduce BAAP's water pumping. Presently, the only reason water is being pumped into the process water system is to recharge the system due to leakage from the pipes. The leakage rate has been as high as 300,000 to 400,000 gallons per day.

The reduced pumping of water from water wells associated with the implementation of the ECOs would therefore reduce energy consumption.

The Pump and Treat Project impacts the BAAP Water Study as follows: Once the Pump and Treat Project is completed, the 500 gpm from the pump and treatment facility will supply the process water system with water (500 gpm is equivalent to 720,000 gallons per day). The process water wells would no longer be required to supply water to the process water system.

We explained to Mr. Owens that any ECOs we came up with would be negated because the pump and treat facility had to pump 500 gpm, essentially providing "free" water. The process water pumps wouldn't have to work, thereby saving energy.

We suggested that we present this issue of free water in the interim report along with other ECOs developed as originally scoped. Questions and/or changes would be addressed at that time. Mr. Owens concurred.

Michael J. Scholz

MJS/kb

Action Required: - NA -

cc: T. BATTAGLIA
D. HARTMAN

If any portion of this Confirmation Notice is incorrect, please notify us immediately. If correspondence is not received to the contrary within 14 days, it will be assumed that the decisions, conclusions, and status outlined in this Confirmation Notice are correct.

ENGINEERS, INC.

2750 South Wadsworth Blvd. • Suite C-200
Denver, Colorado 80227-3400
303/988-2951 • Fax: 303/985-2527

CONFIRMATION NOTICE

Confirmation Notice No. 2 EMC #1406-004

DATE:	14 April 1995
PROJECT:	BAAP Water Conservation Study
CONTRACT NO.:	DACA01-94-D-0033, D.O. No. 4
NOTES PREPARED BY:	E M C Engineers, Inc.
DATE OF MEETING:	11 April 1995
PLACE OF MEETING:	Badger Army Ammunition Plant Baraboo, WI
SUBJECT:	Review Conference Notes - Interim Submittal
ATTENDEES:	Stan Owens, COE - Omaha Ben Hulbert, Army Material Command, IS&A Don Hartmann, BAAP Gov't Bill Wolf, BAAP Olin Randy Sprecher, BAAP Olin Michael Scholz, EMC Tom Poeling, EMC

The following is a summary of the items discussed, the comments made, and the decisions made during the review conference.

The meeting began with an overview of the interim submittal prepared by E M C Engineers, Inc., dated February 1995.

A site audit was performed by E M C Engineers in October 1994. As a part of the site audit, a leak detection survey was performed by M.E. Simpson, Co.. M.E. Simpson used a combination of listening devices and preamplified-transducer systems to identify leak locations. When the location of the leak could not be readily identified using these methods, a leak correlator was used. The correlator determines leak location based on the time it takes for sound to travel from the leak to a waterline connection point.

Sixty-four leaks were identified by the survey on all lines greater than 6" in diameter. A total estimated value of 194,500 gallons per day was separated into:

- 50 fire hydrant leaks: 37,500 gpd
- 5 main line leaks: 143,000 gpd
- 8 valve leaks: 11,000 gpd
- 1 service line leak: 3,000 gpd

BAAP maintenance personnel were able to excavate the location of each of the main leaks. M.E. Simpson personnel were able to make a visual inspection of the leaks and give an estimation of the quantity of leakage using the "bucket-and-stopwatch" method or calculations using the Greeley equation.

From the leak detection survey and site audit, EMC was able to identify four energy conservation opportunities (ECOs) to reduce leakage in the process water system. Reduction in leakage would save pumping, well maintenance, distribution system maintenance and chemical treatment costs. The ECOs identified were:

- **ECO #1.** Fix all leaks identified by the 1994 leak detection survey. The ECO was separated into three separate sub-categories: repair leaks in hydrants, valves and main lines. It was found that repair leaks in main lines was the only ECO that produced a favorable payback. This was due to the fact that repairing main line leaks would save the majority of the total leakage quantity at BAAP with the lowest investment cost.

- **ECO #2.** Clean and reline with concrete three lines designated by BAAP personnel as having historically high occurrences of leakage. A life cycle cost analysis was performed on three separate lines (4,480 feet of 24" diameter steel pipe and 7,095 feet of 14" diameter steel pipe) that took into account current leakage as well as potential future leakage. Potential leakage was quantified through the use of a leakage density factor which presented leakage in terms of the amount of leakage in gallons per day, per linear foot of pipe, per inch diameter of pipe. It was determined that under this specific criteria, cleaning and relining the pipe was not economically feasible.

  Note: It was felt that by focusing the scope of ECO #2 to relining smaller areas of pipe, that the ECO would pay back favorably. Randy Sprecher will talk with BAAP maintenance personnel to determine which specific areas require rehabilitation. EMC will work with BAAP to maximize the amount of pipe that can be rehabilitated and still meet ECIP funding criteria.

- **ECO #3.** Isolate piping that is located in areas classified as "Caretaker" areas. Buildings classified as being in "Caretaker" status are those that BAAP has designated that will no longer require fire protection. Six areas were found that contained buildings in which the process water system could be completely isolated. A life cycle cost analysis was performed that compared the investment cost of isolating the process water system versus the costs of current and future leakage in those areas. The analysis showed that this ECO has a very

favorable payback with a simple payback of just over 1 year and a savings-to-investment ratio (SIR) of 13.1.

- **ECO #4.** Discontinue the practice of chlorinating process water. The potable and process water system are completely isolated and process water is not used for human consumption, therefore, it does not need to be chlorinated to meet safe drinking water standards. This ECO displays a favorable payback because chemical treatment and chemical pumping costs are saved without the need for an initial investment cost.

BAAP is also in the process of constructing a waterline that will connect the new Pump & Treat Facility (IRM) with the process water system. The IRM will be able to supply 500 gpm of high quality water to the process water system, thus significantly reducing the cost of pumping, maintenance, and chemical treatment of the water supplied. This is likely to reduce the payback of the ECOs recommended by this study.

Once the interim report was reviewed, comments supplied by BAAP and Corps of Engineers were reviewed and discussion occurred as to the appropriate implementation of the comments into the final submittal. The following is a summary of the discussion:

1. COMMENT: Water from the pump and treatment facility (IRM) is not free. To pump to the river requires a 100 foot total dynamic head pump (14 HP); whereas, to pump the same amount of water into the process water system requires 211 feet total dynamic head (40 HP).

   RESPONSE: Presently, the IRM facility has two 20 hp pumps to supply water to the present system arrangement. We understand one 20 hp pump will be replaced with a 40 hp pump when the waterline to the process water network is completed.

   It will be assumed that the IRM facility will produce 500 gpm (21,960,000 gallons per month) to the process water system. The average consumption of the process water system over the last three years was 20,900,000 gallons per month (value is based on water consumption logs provided by BAAP personnel). However, over the past three years, the process water system has used more than 21,960,000 gallons per month about four months out of the year (on average). It is estimated that if the wells are used to make up process water demands in excess of 500 gpm, approximately 12 million gallons will be required from the wells. Therefore it will be assumed that out of the total demand of approximately 250,900,000 gallons to the process water system, 12 million gallons (4.8%) are produced from the wells and 238,900,000 gallons (95.2%) will be produced from the IRM facility.

   The total cost of water will be modified to reflect the effects of pumping water from the IRM facility, with process water supplemented by Wells #4 and #5. Specifically, pump energy costs will decrease because the pump horsepower is reduced from 100-125 (Wells 4 and 2, respectively) to 40 hp (IRM facility). Distribution maintenance costs will not change. Chemical treatment costs will not change because chlorination at the IRM facility is meant for the water quality of the process water system, not for chemical treatment of contaminated groundwater at

the BAAP burning grounds. Well maintenance costs will change to reflect a more reasonable breakdown of the maintenance budget (see comment #20).

2. COMMENT: Chlorination of the process water system is not optional since high quality clean bacteria free water is needed for production. The water comes in contact with employees during cleaning operations and emergency showers; It therefore must be safe. Without chlorination, bacteria and algae growth in the large reservoir could not be controlled.

   RESPONSE: We understood BAAP had no production occuring at the time of the survey and we should consider BAAP as not operating for the report. During our interviews, we did not obtain information which would indicate process water was being used for cleaning or for showers. We understood these operations were connected to the potable water system. We understood the water coming from the wells was very clean and safe without the chlorine and the chlorination was required to suspend algae growth in the reservoirs. We deduced since BAAP was not in production and not using water, there would be no chlorination requirement.

   We will remove the ECO #4 from consideration.

3. COMMENT: Repair of unlined steel pipes could never be justified on the basis of leakage only. The cost justification should be based on the increasing cost to repair and the loss of fire protection and plant operations when out of service. These are much harder to quantify, but without a reliable water system, Badger has no value as a back-up propellant production plant and cannot be an industrial site for Facility Contracting. The report should note that no leaks were found in water mains that had been lined.

   RESPONSE: We understand there are other reasons to have an reliable water system such as cost to repair and the value of fire protection and water supply. We cannot comment on BAAP's value as a backup propellant plant.

   The total cost of the process water lost to leakage is a combination of all available information on utility and meter data, maintenance costs, and chemical treatment costs. Allowances were made for future leakage in a life cycle cost analysis through the use of the leakage density calculations and uniform present worth (discount) factors.

   The guidelines we are restricted to, in our evaluation, only allow us to evaluate savings of water associated with saving energy and maintenance costs. We have tried to maintain a close adherance to the guidelines.

   We will mention no leaks were found in waterlines which were cement lined.

4. COMMENT: Report section 2.1.1 and elsewhere, Well #3 is referenced to as abandoned. WDNR has rules concerning abandoned wells and requirements for immediate enclosure. It is not to Badger's advantage to classify this well as abandoned, since it could be used in the future. The well is currently used by the U.S. Geological Survey, Water Resources Division, to continuously monitor local groundwater elevations.

RESPONSE: We will change the wording in the report to reflect Well #3 as a monitoring well and will not refer to it as abandoned.

5. COMMENT: Report section 2.3.1 and elsewhere classifies the process water system as in "poor condition" without comparison to any standard or the other 50 year old water systems. The American Water Works Association (AWWA) has done many studies on evaluation for rehabilitation and replacement of older water systems. Break repair rates per 100 miles per year in one study for the cities of Louisville, Philadelphia, and New York were 22.7, 27.6 and 7.6 respectfully. Badger's rate is about 5.

   RESPONSE: Because the scope of this project is limited to identifying ECOs and determining their energy and maintenance savings and economic feasibility, we will remove references of system classification.

6. COMMENT: In addition to the water main break rates, discussion is necessary on water leakage rates. Badger has a leakage rate estimate by EMC of 194,500 gallons per day in 64 leaks per 75 miles of pipe size between 6 inches and 36 inches. This is a leak rate of 85 per 100 miles whereas 25 is more common value. Analysis of the data indicates 50 of the 64 leaks were due to hydrants not being fully closed. Without the hydrant leaks, the pipe system leak rate is only 12 per 100 miles. Water loss due to breaks and leaks is very high compared to usage since Badger is now in standby. During production, the loss is minor compared to usage. Discussion should address what is reasonable leakage to be expected. The hydrant closing problem has been corrected.

   RESPONSE: We understand and agree with the values presented. Our research at AWWA has produced similar values. We agree with the assessment water loss being minor when compared to the potential or historic operating rate. We also agree that the amount of water lost to leakage becomes magnified because BAAP currently does not have process water uses for production.

   BAAP provided information from a 1989 Wells Engineer report (100% submittal) during the interim review conference that gives a estimate of the anticipated process water requirements for BAAP when it is in full production. EMC will compare the current water usage from leaks to these production values. Discussion as to whether the leakage rate is reasonable will be included in the final report (for a typical municipal water system, the optimum leakage is 3-8% of the total usage).

7. COMMENT: This is the third major leak detection survey performed on the Badger water system. During 1985, Donohue Engineers surveyed the system for $14,040 and found 23 leaks totaling 356,000 gallons per day. During 1990, Pitometer Engineers did a similar leak survey and found 32 new leaks totaling 344,000 gallons per day. This survey cost $11,063. The cost of the current work is not known but an evaluation and recommendation should be made that about every five years, leak detection surveys should be performed. Badger maintenance policy is to repair as soon as possible all known water leaks. Without a survey, these repairs are limited to only those leaks that surface.

RESPONSE: A recommendation for leak detection analyses at a rate of every two years was mentioned in Section 2.3.1 but not included in Section 4. We will include costs and benefits of leak detection in ECO #1 for the final report.

There are items that need to be clarified. According to the studies we reviewed, the Donohue study only covered 10 miles of the facility, not the entire complex. It was assumed that the Donohue study looked at all piping within that area, even smaller diameter piping. It is probably extremely accurate for the area studied, but may not necessarily reflect the condition of the entire process water system at BAAP. The Pitometer study found approximately 202,000 gallons of leakage in 45 leaks. It appears that this study was limited to the larger sized pipe. AWWA manual M36 lists the costs of leak detection at $75 to $300 per mile of main. Based on this information and on the costs of previous studies, it will be assumed that the cost of leak detection to be used in ECO #1 will be about $150 per mile of main.

8. One would expect a bibliography and references used to be included in the report. Water leakage is a problem that has been studied by many groups. Major references include American Water Works Association, Corps of Engineers, American Society of Civil Engineers, and many universities.

   RESPONSES: Please refer to Section 5 for the references. We conducted research at AWWA and should have put their manuals in "References". Those manuals will be included in final document.

9. COMMENT: The last sentence indicates that lining the pipe would be less expensive than replacing it. What is the basis for this statement? Present information justifying this.

   RESPONSE: We will present additional calculations and case studies which indicate lining pipes is less expensive than replacing pipes in the final submittal.

10. COMMENT: It is indicated that the process water may not need to be circulated through the "caretaker" areas and that these areas could be cut off from the process water. However, it should be made sure that there are no chemical storage in the buildings with "caretaker" only status. The existence of chemicals may require a fire protection/prevention system (fire hydrants, etc.) to be in place in the immediate storage area.

    RESPONSE: Water service will only be removed from those areas BAAP deems necessary or appropriate.

11. COMMENT: On sheet #2 of the leakage density calculations, the total leakage discovered by the leakage detection survey is given as 194,500 gal/day. More clearly define how this figure has been estimated.

    RESPONSE: When the pipe leakage is viewed, the flow rate is estimated by the "bucket and stopwatch" method or by the Greeley formula as per AWWA. This is done to calibrate the

instruments. When the technician has calibrated his instrument, no further excavation of pipes is generally required. However, all main leaks were excavated and technicians were able to perform visual inspections. The leakage rate of the fire hydrants is an estimate based upon the problem with the hydrant and the experience of the technician. A complete summary of the leaks found and the estimated quantity of each leak can be found in Appendix C.

12. COMMENT: Page 3, Economic Analysis: It is stated in the first sentence that ECO #4 has favorable economic payback. If it does display it in the table (Table 1) just above the sentence.

    RESPONSE: ECO was a no cost project. ECO #4 will be dropped at BAAP's request. Reference comment response #2.

13. COMMENT: Replace the annual non-energy cost saving figure of $31.975 for ECO #3F with $31,975. This must be a typo.

    RESPONSE: It is a typo.

14. COMMENT: The main body of the report lacks good mapping showing facilities and other references mentioned. The 8 1/2 x 11 maps in appendix B are not clear and very hard to follow.

    RESPONSE: The report came with a large 42" x 36" map, which was acceptable to BAAP personnel. For some reason reviewer did not receive the map. Additional 11" x 17" map(s) are anticipated to be added to the report to provide clarity.

15. COMMENT: How did the actual leak rates compare to the leak rates that were estimated from listening to the leakage noise? Present numbers.

    RESPONSE: In most cases, the leak rate was verified by excavating the leak to get a "bearing" on the site conditions. No record was kept of the before estimate vs. actual leak rate. Once the site conditions were evaluated, no additional excavations were made for comparison.

16. COMMENT: ECO #3 deals with shutting-off the fire protection system water supply to the Caretaker" area buildings. This decision should not be made based on water conservation. The responsible command should make such a decision based on the risks and consequences involved. Based on the data presented in trip report from Mr. Dennis Jones it sounds as if the only purpose of maintaining the process water system is to provide fire protection.

    RESPONSE: BAAP will decide which areas shall be excluded from water service. Recommendations in the report were made from information received from BAAP.

17. COMMENT: Doesn't the second paragraph on page 3.1.2 negate the entire purpose of this study? If the project to connect the treated remediation water to the process water system is already funded doesn't this nullify any savings?

RESPONSE: We presented the information to initiate discussion. Reference comment #1 response.

18. COMMENT: The process used to quantify the size of the leakage problem seem backwards. The amount of water pumped less the amount used in processing should yield the exact amount of leakage. Basing the size of leaks on the frequency of the sound detected seems speculative. The study on page 2-3 indicates that the total process water system uses 687,400 gpd (gallons per day). The process water system leakage is estimated at 194,500 gpd. on page 3-5. If there are no processes currently operating where did the other 492,900 gpd end up?

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    When evaluating water usage, there never is an exact accounting of water losses. Unaccounted water (losses) can be attributed to metering problems, pipe leakage, evaporation of open reservoirs, hydrant testing, and accounting procedures, to name a few. None of these uses are measured at BAAP.

    The leakage rate identification by listening method is a proven technique to locate and estimate water losses (reference AWWA M36). The estimation of water losses is greatly improved when the estimator can calibrate his estimate with a visual inspection, as was done for this survey. The unaccounted water (losses) will be estimated and remaining losses will be attributed to pipe leakage, as concurred with by BAAP personnel.

19. COMMENT: The 1990 report from Pitometer Associates Engineers shows most of the leakage at the hydrants. The Simpson Co. report on the other hand shows most of leakage is in the main piping. This seems to be in conflict.

    RESPONSE:

Pitometer Report:	40 hydrant leaks	168,000 gpd
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Since the majority of BAAP was constructed in 1940's, there is no differential age factors of any consequence. BAAP is constructed in one geographic area, therefore it is reasonable to assume similar soil characteristics. Since the types of pipes used is variable and verification of the pipe type location would be difficult, an assumption of the pipe material would produce values which also average out.

This meeting was adjourned.

Respectfully submitted,

Michael J. Scholz

Michael J. Scholz, Project Manager
mjs/nj

cc: Attendees
Tony Battaglia, COE Mobile
Doug Gray, EMC
Dennis Jones, EMC

If any portion of this Confirmation Notice is incorrect, please notify us immediately. If correspondence is not received to the contrary within 14 days, it will be assumed that the decisions, conclusions, and status outlined in this Confirmation Notice are correct.

EMC ENGINEERS, INC.

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Denver, Colorado 80227-3400
303/988-2951 • Fax: 303/985-2527

CONFIRMATION NOTICE

Confirmation Notice No. 3 EMC #1406-004

DATE: 14 April 1995

PROJECT: BAAP Water Conservation Study
CONTRACT NO.: DACA01-94-D-0033, D.O. No. 4

NOTES PREPARED BY: E M C Engineers, Inc.

SUBJECT: Disposition of Interim Review Comments

1. COMMENT: Water from the pump and treatment facility (IRM) is not free. To pump to the river requires a 100 foot total dynamic head pump (14 HP); whereas, to pump the same amount of water into the process water system requires 211 feet total dynamic head (40 HP).

   RESPONSE: Presently, the IRM facility has two 20 hp pumps to supply water to the present system arrangement. We understand one 20 hp pump will be replaced with a 40 hp pump when the waterline to the process water network is completed.

   It will be assumed that the IRM facility will produce 500 gpm (21,960,000 gallons per month) to the process water system. The average consumption of the process water system over the last three years was 20,900,000 gallons per month (value is based on water consumption logs provided by BAAP personnel). However, over the past three years, the process water system has used more than 21,960,000 gallons per month about four months out of the year (on average). It is estimated that if the wells are used to make up process water demands in excess of 500 gpm, approximately 12 million gallons will be required from the wells. Therefore it will be assumed that out of the total demand of approximately 250,900,000 gallons to the process water system, 12 million gallons (4.8%) are produced from the wells and 238,900,000 gallons (95.2%) will be produced from the IRM facility.

   The total cost of water will be modified to reflect the effects of pumping water from the IRM facility, with process water supplemented by Wells #4 and #5. Specifically, pump energy costs will decrease because the pump horsepower is reduced from 100-125 (Wells 4 and 2, respectively) to 40 hp (IRM facility). Distribution maintenance costs will not change. Chemical treatment costs will not change because chlorination at the IRM facility is meant for the water quality of the process water system, not for chemical treatment of contaminated groundwater at the BAAP burning grounds. Well maintenance costs will change to reflect a more reasonable breakdown of the maintenance budget (see comment #20).

2. COMMENT: Chlorination of the process water system is not optional since high quality clean bacteria free water is needed for production. The water comes in contact with employees during cleaning operations and emergency showers; It therefore must be safe. Without chlorination, bacteria and algae growth in the large reservoir could not be controlled.

   RESPONSE: We understood BAAP had no production occuring at the time of the survey and we should consider BAAP as not operating for the report. During our interviews, we did not obtain information which would indicate process water was being used for cleaning or for showers. We understood these operations were connected to the potable water system. We understood the water coming from the wells was very clean and safe without the chlorine and the chlorination was required to suspend algae growth in the reservoirs. We deduced since BAAP was not in production and not using water, there would be no chlorination requirement.

   We will remove the ECO #4 from consideration.

3. COMMENT: Repair of unlined steel pipes could never be justified on the basis of leakage only. The cost justification should be based on the increasing cost to repair and the loss of fire protection and plant operations when out of service. These are much harder to quantify, but without a reliable water system, Badger has no value as a back-up propellant production plant and cannot be an industrial site for Facility Contracting. The report should note that no leaks were found in water mains that had been lined.

   RESPONSE: We understand there are other reasons to have an reliable water system such as cost to repair and the value of fire protection and water supply. We cannot comment on BAAP's value as a backup propellant plant.

   The total cost of the process water lost to leakage is a combination of all available information on utility and meter data, maintenance costs, and chemical treatment costs. Allowances were made for future leakage in a life cycle cost analysis through the use of the leakage density calculations and uniform present worth (discount) factors.

   The guidelines we are restricted to in our evaluation only allow us to evaluate savings of water associated with saving energy and maintenance costs. We have tried to maintain a close adherance to the guidelines.

   We will mention no leaks were found in waterlines which were cement lined.

4. COMMENT: Report section 2.1.1 and elsewhere, Well #3 is referenced to as abandoned. WDNR has rules concerning abandoned wells and requirements for immediate enclosure. It is not to Badger's advantage to classify this well as abandoned, since it could be used in the future. The well is currently used by the U.S. Geological Survey, Water Resources Division, to continuously monitor local groundwater elevations.

   RESPONSE: We will change the wording in the report to reflect Well #3 as a monitoring well and will not refer to it as abandoned.

5. COMMENT: Report section 2.3.1 and elsewhere classifies the process water system as in "poor condition" without comparison to any standard or the other 50 year old water systems. The American Water Works Association (AWWA) has done many studies on evaluation for rehabilitation and replacement of older water systems. Break repair rates per 100 miles per year in one study for the cities of Louisville, Philadelphia, and New York were 22.7, 27.6 and 7.6 respectfully. Badger's rate is about 5.

   RESPONSE: Because the scope of this project is limited to identifying ECOs and determining their energy and maintenance savings and economic feasibility, we will remove references of system classification.

6. COMMENT: In addition to the water main break rates, discussion is necessary on water leakage rates. Badger has a leakage rate estimate by EMC of 194,500 gallons per day in 64 leaks per 75 miles of pipe size between 6 inches and 36 inches. This is a leak rate of 85 per 100 miles whereas 25 is more common value. Analysis of the data indicates 50 of the 64 leaks were due to hydrants not being fully closed. Without the hydrant leaks, the pipe system leak rate is only 12 per 100 miles. Water loss due to breaks and leaks is very high compared to usage since Badger is now in standby. During production, the loss is minor compared to usage. Discussion should address what is reasonable leakage to be expected. The hydrant closing problem has been corrected.

   RESPONSE: We understand and agree with the values presented. Our research at AWWA has produced similar values. We agree with the assessment water loss being minor when compared to the potential or historic operating rate. We also agree that the amount of water lost to leakage becomes magnified because BAAP currently does not have process water uses for production.

   BAAP provided information from a 1989 Wells Engineer report (100% submittal) during the interim review conference that gives a estimate of the anticipated process water requirements for BAAP when it is in full production. EMC will compare the current water usage from leaks to these production values. Discussion as to whether the leakage rate is reasonable will be included in the final report (for a typical municipal water system, the optimum leakage is 3-8% of the total usage).

7. COMMENT: This is the third major leak detection survey performed on the Badger water system. During 1985, Donohue Engineers surveyed the system for $14,040 and found 23 leaks totaling 356,000 gallons per day. During 1990, Pitometer Engineers did a similar leak survey and found 32 new leaks totaling 344,000 gallons per day. This survey cost $11,063. The cost of the current work is not known but an evaluation and recommendation should be made that about every five years, leak detection surveys should be performed. Badger maintenance policy is to repair as soon as possible all known water leaks. Without a survey, these repairs are limited to only those leaks that surface.

RESPONSE: A recommendation for leak detection analyses at a rate of every two years was mentioned in Section 2.3.1 but not included in Section 4. We will include costs and benefits of leak detection in ECO #1 for the final report.

There are items that need to be clarified. According to the studies we reviewed, the Donohue study only covered 10 miles of the facility, not the entire complex. It was assumed that the Donohue study looked at all piping within that area, even smaller diameter piping. It is probably extremely accurate for the area studied, but may not necessarily reflect the condition of the entire process water system at BAAP. The Pitometer study found approximately 202,000 gallons of leakage in 45 leaks. It appears that this study was limited to the larger sized pipe. AWWA manual M36 lists the costs of leak detection at $75 to $300 per mile of main. Based on this information and on the costs of previous studies, it will be assumed that the cost of leak detection to be used in ECO #1 will be about $150 per mile of main.

8. One would expect a bibliography and references used to be included in the report. Water leakage is a problem that has been studied by many groups. Major references include American Water Works Association, Corps of Engineers, American Society of Civil Engineers, and many universities.

   RESPONSES: Please refer to Section 5 for the references. We conducted research at AWWA and should have put their manuals in "References". Those manuals will be included in final document.

9. COMMENT: The last sentence indicates that lining the pipe would be less expensive than replacing it. What is the basis for this statement? Present information justifying this.

   RESPONSE: We will present additional calculations and case studies which indicate lining pipes is less expensive than replacing pipes in the final submittal.

10. COMMENT: It is indicated that the process water may not need to be circulated through the "caretaker" areas and that these areas could be cut off from the process water. However, it should be made sure that there are no chemical storage in the buildings with "caretaker" only status. The existence of chemicals may require a fire protection/prevention system (fire hydrants, etc.) to be in place in the immediate storage area.

    RESPONSE: Water service will only be removed from those areas BAAP deems necessary or appropriate.

11. COMMENT: On sheet #2 of the leakage density calculations, the total leakage discovered by the leakage detection survey is given as 194,500 gal/day. More clearly define how this figure has been estimated.

    RESPONSE: When the pipe leakage is viewed, the flow rate is estimated by the "bucket and stopwatch" method or by the Greeley formula as per AWWA. This is done to calibrate the instruments. When the technician has calibrated his instrument, no further excavation of pipes is

generally required. However, all main leaks were excavated and technicians were able to perform visual inspections. The leakage rate of the fire hydrants is an estimate based upon the problem with the hydrant and the experience of the technician. A complete summary of the leaks found and the estimated quantity of each leak can be found in Appendix C.

12. COMMENT: Page 3, Economic Analysis: It is stated in the first sentence that ECO #4 has favorable economic payback. If it does display it in the table (Table 1) just above the sentence.

    RESPONSE: ECO was a no cost project. ECO #4 will be dropped at BAAP's request. Reference comment response #2.

13. COMMENT: Replace the annual non-energy cost saving figure of $31.975 for ECO #3F with $31,975. This must be a typo.

    RESPONSE: It is a typo.

14. COMMENT: The main body of the report lacks good mapping showing facilities and other references mentioned. The 8 1/2 x 11 maps in appendix B are not clear and very hard to follow.

    RESPONSE: The report came with a large 42" x 36" map, which was acceptable to BAAP personnel. For some reason reviewer did not receive the map. Additional 11" x 17" map(s) are anticipated to be added to the report to provide clarity.

15. COMMENT: How did the actual leak rates compare to the leak rates that were estimated from listening to the leakage noise? Present numbers.

    RESPONSE: In most cases, the leak rate was verified by excavating the leak to get a "bearing" on the site conditions. No record was kept of the before estimate vs. actual leak rate. Once the site conditions were evaluated, no additional excavations were made for comparison.

16. COMMENT: ECO #3 deals with shutting-off the fire protection system water supply to the Caretaker" area buildings. This decision should not be made based on water conservation. The responsible command should make such a decision based on the risks and consequences involved. Based on the data presented in trip report from Mr. Dennis Jones it sounds as if the only purpose of maintaining the process water system is to provide fire protection.

    RESPONSE: BAAP will decide which areas shall be excluded from water service. Recommendations in the report were made from information received from BAAP.

17. COMMENT: Doesn't the second paragraph on page 3.1.2 negate the entire purpose of this study? If the project to connect the treated remediation water to the process water system is already funded doesn't this nullify any savings?

    RESPONSE: We presented the information to initiate discussion. Reference comment #1 response.

18. COMMENT: The process used to quantify the size of the leakage problem seem backwards. The amount of water pumped less the amount used in processing should yield the exact amount of leakage. Basing the size of leaks on the frequency of the sound detected seems speculative. The study on page 2-3 indicates that the total process water system uses 687,400 gpd (gallons per day). The process water system leakage is estimated at 194,500 gpd. on page 3-5. If there are no processes currently operating where did the other 492,900 gpd end up?

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Respectfully submitted,

Michael J. Scholz

Michael J. Scholz, Project Manager
mjs/tp

Attachments: Attachment 1

cc: Mr. Tony Battaglia, COE Mobile (w/attachment)
Mr. Stan Owens, COE Omaha (w/attachment)
Mr. John Nache & Mr. Ben Hulbert, Army Material Command, IS&A (1 copy w/attachment)
Mr. Don Hartmann, BAAP Gov't (w/attachment)
Mr. J.R. Mattei, Director of Operations, BAAP (w/attachment)

EMC ENGINEERS, INC.

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18 July 1995

EMC #1406-004

Mr. Stan Owens
U.S. Army Corps of Engineers
215 North 17th Street
Omaha, NE 68102-4978

Re: Final comments and responses for the Badger Army Ammunition Plant water and energy study

Dear Stan:

Here is a restating of each comment produced by Corps of Engineers, Mr. Okan Nalbant and our disposition. There are only two comments from BAAP which required disposition, and they are also included here.

1. Comment #1 Correct the figure corresponding to annual water savings associated with ECO#2. It should be 54.636.

   Disposition: We will correct.

2. Comment #2 Have the reader refer to the appropriate map(s) to locate the proposed ECO #2, and ECO #3 applications mentioned here.

   Disposition: We will make appropriate references.

3. Comment #3 The process water system maps do not indicate estimated flow values for the leaks associated with the leakage locations as required by the Detailed Scope of Work (Annex A).

   Disposition: A site plan map will be included to meet the Detailed Scope of Work (Annex A).

4. Comment # 4 The table references to EMC drawings, however, these drawings could not be located in the report.

   Disposition: The references to drawings were for in-house use and will be deleted from "Summary Table". The new table is included here as well.

5. Comment #5 Present typical cost of replacing existing water lines for comparison to the cost of relining that were estimated.

Disposition: Typical costs for relining and replacing pipe will be inserted into the document. They are included here as well.

6. Comment #6 Number pages in Appendices for easier reference.

   Disposition: Respectfully disagree. Reference made in text only refer to the appendices in whole. No specific appendix page number is referenced. As mentioned on the cover letter (attached) only those pages requiring changes should be reissued. To number the individual appendix pages would essentially require reissuing the entire report.

7. Comment #7 Figure 2-2 indicates that a portion of a 24" pipe running north to south is within the boundary of caretaker area #8. If ECO #2 (clean pipe and reline) and ECO #3 (isolator caretaker areas) were both to be implemented; then neither savings nor costs associated with implemented ECO #2 for the subject portion of the piping should be realized. Either note this or adjust your calculations accordingly.

   Disposition: The 24 inch pipe is not a part of the caretaker area. The 24 inch pipe supplies areas and waterlines which are included in the caretaker area. These lines will be abandoned at the closest valve to the 24 inch main as described in ECO # 3. The 24 inch line is a part of ECO # 2 and does not participate in ECO #3.

8. Comment #8: Include a project/location map in the report as well as a site plan for reference.

   Disposition: A project/location map and a site plan will be incorporated in report. The site map was in the interim document but was inadvertently omitted from the final document.

9. Comment #9: Another recommendation for the plant would be recommending that the plant conduct a new survey to update the caretaker status of the areas that apply. It is possible that more caretaker areas may be identified which may translate into additional energy and cost savings.

   Disposition: This is not an action item for EMC Engineers, Inc.

10. Comment # 3 from BAAP: We will attempt to obtain funding for the four energy conservation opportunities identified through Army Energy/Cost Programs using the 1391 forms and supporting documents as developed.

    Disposition: We want to submit a point of clarification. We have really only submitted three energy conservation opportunities. ECO # 1 and ECO # 4 are essentially the same ECO's separated by the implementation of ECO's number 2 and 3. In other words, ECO #1 should be implemented before ECO's number 2 and 3 and ECO # 4 implemented after ECO's number 2 and 3.

11. Comment #4 from BAAP: Please have EMC Engineers provide 3½ computer disks of CAD drawings they developed for the report.

Disposition: We will provide BAAP with a 3 ½" computer disk of the CAD drawings developed for the report.

If you have any questions feel free to contact me.

Sincerely,

EMC ENGINEERS, INC.

Michael J. Scholz

Michael Scholz

cc: D. Jones
T. Poeling

Attachments

MJS:nj w:\mike_s\1406-004\comments.doc

E M C Engineers, Inc.
Badger Army Ammunition Plant
EMC #1406-004

Leak Detection Summary

Prepared by: T Poeling
7/26/95
Checked by: _______

Response to
Comment #4 BAAP

BADGER ARMY AMMUNITIONS PLANT LEAK SUMMARY

TYPE OF LEAK	LOCATION/ DESCRIPTION	SIZE (GPD)	CARETAKER AREA NO.	FULL/PARTIAL CARETAKER	COMMENTS/ PIPE/VALVE SIZE
Fire Hydrant	Hydrant #2	750	-		
Valve - Packing	Valve #N20750	750	21	Partial	1-1/2" Valve
Fire Hydrant	Hydrant #3	750	-		
Fire Hydrant	Hydrant #4	750	-		
Fire Hydrant	Hydrant #11	750	1	Full	
Fire Hydrant	Hydrant #25	750	22	Partial	
Fire Hydrant	Hydrant #133	750	24	Partial	
Fire Hydrant	Hydrant #153	750	-		Quit leaking when tightened
Fire Hydrant	Hydrant #63	750	-		
Fire Hydrant	Hydrant #76	750	-		
Main Line	Near Bldg 4508-1 by Hydrant #177	3,000	12	Full	16" Line
Service Line	Bldg. 4506	3,000	12		Quit leaking when tightened
Valve	Valve #185	2,000	-		24" Valve
Valve	Valve #325 (323)	2,000	-		16" Valve
Fire Hydrant	Hydrant #91	750	-		
Valve - Packing	Valve #F10	750	8	Partial	24" Valve
Valve - Packing	Valve #338	750	8	Full	24" Valve
Valve	Valve #E2455	2,000	8	Full	24" Valve
Fire Hydrant	Hydrant #271	750	-		
Fire Hydrant	Hydrant #396	750	1	Full	
Main Line	Across from Bldg. #1600-33	35,000	-		14" Line
Fire Hydrant	Hydrant #298	750	-		
Fire Hydrant	Hydrant #374P	750	-		
Main Line	Next to Hyd. #239	35,000	-		14" Line
Fire Hydrant	Hydrant #241	750	-		
Fire Hydrant	Hydrant #242	750	-		
Fire Hydrant	Hydrant #278	750	-		
Fire Hydrant	Hydrant #279	750	-		
Fire Hydrant	Hydrant #379	750	-		
Fire Hydrant	Hydrant #356	750	11	Partial	
Fire Hydrant	Hydrant #406	750	-		
Fire Hydrant	Hydrant #450	750	3	Partial	
Fire Hydrant	Hydrant #254	750	12	Full	
Fire Hydrant	Hydrant #344	750	12	Full	
Main Line	Near Bldg. 1996-17	35,000	13	Partial	14" Line
Fire Hydrant	Hydrant #319	750	13	Full	
Fire Hydrant	Hydrant #347	750	12	Partial	
Fire Hydrant	Hydrant #473	750	16	Partial	
Fire Hydrant	Hydrant #475	750	16	Partial	
Main Line	Near Bldg. 1650-41	35,000	-		14" Line
Fire Hydrant	Hydrant #266	750	-		
Fire Hydrant	Hydrant #267	750	-		
Fire Hydrant	Hydrant #504	750	17		Quit leaking when tightened
Fire Hydrant	Hydrant #508	750	17	Partial	
Fire Hydrant	Hydrant #518	750	17	Partial	

E M C Engineers, Inc.
Badger Army Ammunition Plant
EMC #1406-004

Leak Detection Summary

Prepared by: T Poeling
7/26/95
Checked by: _______

TYPE OF LEAK	LOCATION/ DESCRIPTION	SIZE (GPD)	CARETAKER AREA NO.	FULL/PARTIAL CARETAKER	COMMENTS/ PIPE/VALVE SIZE
Fire Hydrant	Hydrant #464 (564)	750	17	Partial	
Fire Hydrant	Hydrant #548	750	17	Partial	
Fire Hydrant	Hydrant #549	750	17	Partial	
Fire Hydrant	Hydrant #555	750	17	Partial	
Fire Hydrant	Hydrant #556	750	17		Quit leaking when tightened
Fire Hydrant	Hydrant #567	750	17	Partial	
Fire Hydrant	Hydrant #573	750	17	Partial	
Fire Hydrant	Hydrant #577	750	17	Partial	
Fire Hydrant	Hydrant #584	750	18		Quit leaking when tightened
Fire Hydrant	Hydrant #640	750	18	Full	
Fire Hydrant	Hydrant #513	750	17	Partial	
Fire Hydrant	Hydrant #526	750	17	Partial	
Fire Hydrant	Hydrant #529	750	17	Partial	
Valve - Packing	Valve #162	2,000	17	Full	16" Valve
Fire Hydrant	Hydrant #551	750	17	Partial	
Fire Hydrant	Hydrant #571	750	17		Quit leaking when tightened
Fire Hydrant	Hydrant #592	750	18	Partial	
Fire Hydrant	Hydrant #421	750	-		
Valve - Packing	Valve #353	750	-		6" Valve

SUMMARY

Total Loss - Main Line	143,000
Total Loss - Valves	6,000
Total Loss - Packing Valves	5,000
Total Loss - Service Line	3,000
Total Loss - Fire Hydrants	37,500
Total Loss - All Leaks (GPD)	194,500

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(303) 988-2951

Response to Comment #5 BAAP

JOB 1406 004 BAAP
SHEET NO. ____ OF ____
CALCULATED BY TCP DATE 7-12-95
CHECKED BY ____ DATE ____
SCALE ECO #2 - LCCA

ECO #2 - Cost Comparison: Pipe Relining vs. Pipe Replacement

- All unit costs taken from Means Mechanical Cost Data (1995)
- Assume 24" diameter pipe

Relining Pipe (Per LF)

Item	Unit	Qty/LF	Unit Material	Unit Labor	Unit Equip.	Total
Excavation	CY	0.667	$0.00	$1.48	$1.51	$2.00
Pipe Lining	LF	1.0	$18.30	$28.60	$0.84	$47.74
Crushed Bedding	CY	0.222	$13.00	$3.28	$1.33	$3.91
Backfill	CY	0.445	$0.00	$0.68	$0.56	$0.55
Compaction	CY	0.667	$0.00	$0.82	$0.32	$0.76

Total/LF = $54.96

Replacing Pipe (Per LF)

Item	Unit	Qty/LF	Unit Material	Unit Labor	Unit Equip	Total
Excavation	CY	0.667	$0.00	$1.48	$1.51	$2.00
Pipe Removal	LF	1.0	$0.00	$4.09	$1.66	$5.75
Piping, 24"	LF	1.0	$45.50	$18.60	$4.32	$68.42
Crushed Bedding	CY	0.222	$13.00	$3.28	$1.33	$3.91
Backfill	CY	0.445	$0.00	$0.68	$0.56	$0.55
Compaction	CY	0.667	$0.00	$0.82	$0.32	$0.76

Total/LF = $81.39

A comparison of the piping for ECO #2 follows. The difference between replacing vs relining = $896,393 - $647,032 = $249,361

ENGINEER'S OPINION OF PROBABLE COST

SHEET 1 OF 1

AREA	ACTIVITY	LOCATION	AMENDMENT NO.
Baraboo, Wisconsin	Leak Detection Study	Badger Army Ammunition Plant	

PROJECT TITLE	CONTRACT NO.
ECO #2 - REPLACE PROBLEM PIPING AREAS (Alternative)	DACA01-94-D-0033

Line No.	Item Description	Unit of Measure	Qty.	MATERIAL COST Unit Cost	MATERIAL COST Total	LABOR COST Unit Cost	LABOR COST Total	EQUIPMENT COST Unit Cost	EQUIPMENT COST Total	TOTAL COST Unit Cost	TOTAL COST Total
1	**RELINING PIPING**										
2	EXCAVATION	CY	6,800	$0.00	$0	$1.48	$10,064	$1.51	$10,268	$2.99	$20,332
3	DEWATERING	DAY	4	$0.00	$0	$67.50	$270	$7.80	$31	$75.30	$301
4	PIPE REMOVAL, TO 24" DIA.	LF	6,720	$0.00	$0	$4.09	$27,485	$1.66	$11,155	$5.75	$38,640
5	PIPE REMOVAL, TO 24" DIA.	LF	4,890	$0.00	$0	$4.09	$20,000	$1.66	$8,117	$5.75	$28,118
6	PIPING, 14"	LF	6,720	$23.00	$154,560	$11.45	$76,944	$1.92	$12,902	$36.37	$244,406
7	PIPING, 24"	LF	4,890	$45.50	$222,495	$18.60	$90,954	$4.32	$21,125	$68.42	$334,574
8	CRUSHED ROCK BEDDING	CY	2,260	$13.00	$29,380	$3.28	$7,413	$1.33	$3,006	$17.61	$39,799
9	BACKFILL	CY	4,540	$0.00	$0	$0.68	$3,087	$0.56	$2,542	$1.24	$5,630
10	COMPACTION	CY	6,800	$0.00	$0	$0.82	$5,576	$0.32	$2,176	$1.14	$7,752
11											
12											
13											
14											
15											
16											
17	**CONSTRUCTION SUBTOTAL**				$406,435		$241,793		$71,323		$719,551
18	LOCATION FACTOR	%		74.20%	$301,575	101.10%	$244,453	100.00%	$71,323		$617,351
19	OVERHEAD & BOND	%	20		$60,315		$48,891		$14,265		$123,470
20	SUBTOTAL				$361,890		$293,343		$85,588		$740,821
21	PROFIT	%	10		$36,189		$29,334		$8,559		$74,082
22	SUBTOTAL				$398,079		$322,677		$94,147		$814,903
23	CONTINGENCY	%	10		$39,808		$32,268		$9,415		$81,490
24	**GRAND TOTAL**				$437,887		$354,945		$103,661		$896,393

PREPARED BY	APPROVED BY	TITLE OR ORGANIZATION	DATE
TCP		E M C Engineers, Inc.	7/11/95

ENGINEER'S OPINION OF PROBABLE COST

SHEET 1 OF 1

AREA	ACTIVITY	LOCATION	AMENDMENT NO.
Baraboo, Wisconsin	Leak Detection Study	Badger Army Ammunition Plant	

PROJECT TITLE	CONTRACT NO.
ECO #2 - RELINING PROBLEM PIPING AREAS	DACA01-94-D-0033

Line No.	Item Description	Unit of Measure	Qty.	MATERIAL COST		LABOR COST		EQUIPMENT COST		TOTAL COST	
				Unit Cost	Total	Unit Cost	Total	Unit Cost	Total	Unit Cost	Total
1	RELINING PIPING										
2	EXCAVATION	CY	1,080	$0.00	$0	$1.48	$1,598	$1.51	$1,631	$2.99	$3,229
3	DEWATERING	DAY	2	$0.00	$0	$67.50	$135	$7.80	$16	$75.30	$151
4	PIPE LINING, 12" (14")	LF	6,720	$14.30	$96,096	$21.70	$145,824	$0.64	$4,301	$36.64	$246,221
5	PIPE LINING, 24"	LF	4,890	$18.30	$89,487	$28.60	$139,854	$0.84	$4,108	$47.74	$233,449
6	CRUSHED ROCK BEDDING	CY	360	$13.00	$4,680	$3.28	$1,181	$1.33	$479	$17.61	$6,340
7	BACKFILL	CY	720	$0.00	$0	$0.68	$490	$0.56	$403	$1.24	$893
8	COMPACTION	CY	1,080	$0.00	$0	$0.82	$886	$0.32	$346	$1.14	$1,231
9											
10											
11											
12											
13											
14											
15											
16											
17	**CONSTRUCTION SUBTOTAL**				$190,263		$289,967		$11,282		$491,513
18	LOCATION FACTOR	%		74.20%	$141,175	101.10%	$293,157	100.00%	$11,282		$445,615
19	OVERHEAD & BOND	%	20		$28,235		$58,631		$2,256		$89,123
20	SUBTOTAL				$169,410		$351,788		$13,539		$534,738
21	PROFIT	%	10		$16,941		$35,179		$1,354		$53,474
22	SUBTOTAL				$186,351		$386,967		$14,893		$588,211
23	CONTINGENCY	%	10		$18,635		$38,697		$1,489		$58,821
24	**GRAND TOTAL**				$204,986		$425,664		$16,382		$647,032

PREPARED BY	APPROVED BY	TITLE OR ORGANIZATION	DATE
TCP		E M C Engineers, Inc.	7/11/95

DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS, OMAHA DISTRICT
215 NORTH 17TH STREET
OMAHA, NEBRASKA 68102-4978

REPLY TO
ATTENTION OF

July 5, 1995

Military/Civil Engineering
Management Branch

EMC Engineers, Inc.
Suite C-200
2750 South Wadsworth Boulevard
Denver, Colorado 80227-3400

Gentleman:

Enclosed are review comments for the Final Submittal of the Water Conservation Study at Badger Army Ammunition Plant, Wisconsin. We request that you make any necessary changes to the study and annotate the action taken for each comment. If necessary, revised sheets may be issued to insert into the study in lieu of reproducing the entire study.

Should you have any questions regarding this request, please contact Mr. Stan Owens of this office, at telephone (402) 221-4523.

Sincerely,

Daniel L. Sommer

Daniel L. Sommer, P.E.
Authorized Representative of the
Contracting Officer

Enclosure

T Foeling
D. Jones

DEPARTMENT OF THE ARMY
BADGER ARMY AMMUNITION PLANT
BARABOO, WISCONSIN 53913

REPLY TO
ATTENTION OF

SMCBA-OR

15 June 1995

MEMORANDUM FOR Commander, Omaha District Corps of Engineers, ATTN: CEMRO-ED-MC, 215 N. 17th St., Omaha, NE 68102-4978

SUBJECT: Water Conservation Study, Energy Engineering Analysis Program (EEAP), FY94, Badger Army Ammunition Plant, Wi

1. Reference CEMRO-ED-MC memorandum dated 23 May 1995, SAB..

TLP 2. The Engineer's Final Report on the subject project meets the intent of the contract and addresses the concerns discussed at the April 1995 review meeting.

TLP 3. We will attempt to obtain funding for the four energy conservation opportunities identified through Army Energy/Cost Programs using the 1391 forms and supporting documents as developed.

8 APL 4. Please have EMC Engineers provide 3½" computer disks of the CAD drawings they developed for the report.

4. Point of contract is Donald L. Hartmann, SMCBA-OR, 608-356-5525, Ext. 328.

FOR THE COMMANDER:

Donald L Hartmann

DONALD L. HARTMANN
Acting Commander's Representative

CORPS OF ENGINEERS REVIEW COMMENTS	SHEET 1 OF 2
	DATE: June 16, 1995
OMAHA DISTRICT	TO: Stan Owens
A/E: EMC Engineers, Inc.	REQUEST: Review Final Report, Water Conservation Study
PROJECT: Water Conservation Study	LOCATION: Badger Army Ammunition Plant, Wisconsin
COMMENTS BY: Nalbant, Okan M.	BRANCH/SECTION: CEMRO-ED-DK

	DRAWING # OR PARAGRAPH #	CMT #	COMMENT	ACTION
TCP KB	Executive Summary Table 1, Page 3	1	Correct the figure corresponding to annual water savings associated with ECO #2. It should be 54.636.	
TCP KB	Executive Summary Recommendations	2	Have the reader refer to the appropriate map(s) to locate the proposed ECO #2, and ECO #3 applications mentioned here.	
	Par. 2 Figures 2-1,2-2,2-3	3	The process water system maps do not indicate estimated flow values for the leaks associated with the leakage locations as required by the Detailed Scope of Work (Annex A).	
TCP	Appendix C, Leak Detection Summary Table	4	The table references to EMC drawings, however, these drawings could not be located in the report.	
CP	Appendix D ECO #2: Relining Pipes	5	Present typical cost of replacing existing water lines for comparison to the cost of relining that were estimated.	
MJS	General	6	Number pages in Appendices for easier reference.	
MJS	General	7	Figure 2-2 indicates that a portion of a 24" pipe running north to south is within the boundary of caretaker area #8. If ECO #2 (clean pipe and reline) and ECO #3 (isolate caretaker areas) were both to be implemented; then neither savings nor costs associated with implementing ECO #2 for the subject portion of the piping, should be realized. Either note this or adjust your calculations accordingly.	
GAL	General	8	Include a project/location map in the report as well as a site plan for reference.	

General MJS	9	Another recommendation for the plant would be recommending that the plant conduct a new survey to update the caretaker status of the areas that apply. It is possible that more caretaker areas may be identified which may translate into additional energy and cost savings.

Attachment 1

DEPARTMENT OF THE ARMY
BADGER ARMY AMMUNITION PLANT
BARABOO, WISCONSIN 53913 – 5000

REPLY TO
ATTENTION OF

SMCBA-OR

16 March 1995

MEMORANDUM FOR Commander, Omaha District Corps of Engineers, ATTN: CEMRO-ED-MC, 215 N. 17th St., Omaha, NE 68102-4978

SUBJECT: Water Conservation Study, Energy Engineering Analysis Program (EEAP), FY94, Badger Army Ammunition Plant, Wi

1. Reference CEMRO-ED-MC memorandum dated 24 February 1995, SAB..

2. Subject Water Study has been reviewed and comments are contained in the attached Olin letter dated 13 March 1995, SAB.

3. This office concurs with the attached comments. In addition, the date the study was done should be in the report.

4. Point of contract is Donald L. Hartmann, SMCBA-OR, 608-356-5525, Ext. 328.

FOR THE COMMANDER:

Jack H. Coyle, Jr.

Att

JACK H. COYLE, JR.
Acting Commander's Representative

13 March 1995

Contracting Officer's Representative
Badger Army Ammunition Plant
Baraboo, Wisconsin 53913

Subject: Water Conservation Study

Reference: Industrial Engineer letter, dated 21 February 1995, same subject

Dear Sir:

The referenced letter transmitted a water conservation study interim report prepared by EMC Engineers, Inc. under a COE contract and requested our comments.

We were very satisfied with the work done by the M.E. Simpson Company, EMC's subcontractor, to locate existing leaks in the Badger water system. They were very professional, accurate, and generous with sharing their expertise and information. Our maintenance staff is working on fixing leaks they found and Badger will be changing its hydrant closing policy, which should reduce some of the fire hydrant leak problems.

We have reviewed the EMC Engineers, Inc. report and offer the following comments:

1. Water from the pump and treatment facility (IRM) is not free. To pump to the river requires a 100 foot total dynamic head pump (14 HP); whereas, to pump the same amount of water into the process water system requires 211 feet total dynamic head (40 HP).

2. Chlorination of the process water system is not optional since high quality clean bacteria free water is needed for production. The water comes in contact with employees during cleaning operations and emergency showers; it therefore must be safe. Without chlorination, bacteria and algae growth in the large reservoir could not be controlled.

3. Repair of unlined steel pipes could never be justified on the basis of leakage only. The cost justification should be based on the increasing cost to repair and the loss of fire protection and plant operations when out of service. These are much harder to quantify, but without a reliable water system, Badger has no value as a back-up propellant production plant and cannot be an industrial site for Facility Contracting. The report should note that no leaks were found in watermains that had been lined.

4. Report section 2.1.1 and elsewhere, Well #3 is referenced to as abandoned. WDNR has rules concerning abandoned wells and requirements for immediate enclosure. It is not to Badger's advantage to classify this well as abandoned, since it could be used in the future. The well is currently used by the U.S. Geological Survey, Water Resources Division, to continuously monitor local groundwater elevations.

5. Report section 2.3.1 and elsewhere classifies the process water system as in "poor condition" without comparison to any standard or to other 50 year old water systems. The American Water Works Association (AWWA) has done many studies on evaluation for rehabilitation and replacement of older water systems. Break repair rates per 100 miles per year in one study for the cities of Louisville, Philadelphia, and New York were 22.7, 27.6 and 7.6 respectfully. Badger's rate is about 5.

6. In addition to the watermain break rates, discussion is necessary on water leakage rates. Badger has a leakage rate estimate by EMC of 194,500 gallons per day in 64 leaks per 75 miles of pipe size between 6 inches and 36 inches. This is a leak rate of 85 per 100 miles whereas 25 is more common value. Analysis of the data indicates 50 of the 64 leaks were due to hydrants not being fully closed. Without the hydrant leaks, the pipe system leak rate is only 12 per 100 miles. Water loss due to breaks and leaks is very high compared to usage since Badger is now in standby. During production, the loss is minor compared to usage. Discussion should address what is reasonable leakage to be expected. The hydrant closing problem has been corrected.

7. This is the third major leak detection survey performed on the Badger water system. During 1985, Donohue Engineers surveyed the system for $14,040 and found 23 leaks totaling 356,000 gallons per day. During 1990, Pitometer Engineers did a similar leak survey and found 32 new leaks totaling 344,000 gallons per day. This survey cost $11,063. The cost of the current work is not known but an evaluation and recommendation should be made that about every five years, leak detection surveys should be performed. Badger maintenance policy is to repair as soon as possible all known water leaks. Without a survey, these repairs are limited to only those leaks that surface.

8. One would expect a bibliography and references used to be included in the report. Water leakage is a problem that has been studied by many groups. Major references include American Water Works Association, Corps of Engineers, American Society of Civil Engineers, and many universities.

Very truly yours,

ORIGINAL SIGNED BY
J.R. MATTEI

J. R. MATTEI
Director of Operations

LMU/WJW/rn

CORPS OF ENGINEERS REVIEW COMMENTS	SHEET 1 OF 1
	DATE: March 15, 1995
OMAHA DISTRICT	TO: Stan Owens
A/E: EMC Engineers, Inc.	REQUEST: Review Interim Report (50%) on Water Conservation Study
PROJECT: Water Conservation Study	LOCATION: Badger Army Ammunition Plant, Wisconsin
COMMENTS BY: Nalbant, Okan M.	BRANCH/SECTION: CEMRO-ED-DK

DRAWING # OR PARAGRAPH #	CMT #	COMMENT	ACTION
Par. 3.3.2, page 3-7	9 ~~1~~	The last sentence indicates that lining the pipe would be less expensive than replacing it. What is the basis for this statement? Present information justifying this.	
Par. 3.3.3, page 3-9	10 ~~2~~	It is indicated that the process water may not need to be circulated through the "caretaker" areas and that these areas could be cut off from the process water. However, it should be made sure that there are no chemical storage in the buildings with "caretaker" only status. The existence of chemicals may require a fire protection/prevention system (fire hydrants, etc.) to be in place in the immediate storage area.	
Appendix D - C?	11 ~~3~~	On sheet #2 of the leakage density calculations, the total leakage discovered by the leakage detection survey is given as 194,500 gal/day. More clearly define how this figure has been estimated.	
EXEC. SUMMARY	12 ~~4~~	Page 3, Economic Analysis: It is stated in the first sentence that ECO #4 has favorable economic payback. If it does display it in the table (Table 1) just above the sentence.	
TABLE 3-5, page 3-10	~~5~~ 13	Replace the annual non-energy cost saving figure of $31.975 for ECO #3F with $31,975. This must be a typo.	
GENERAL	14 ~~6~~	The main body of the report lacks good mapping showing facilities and other references mentioned. The 8 1/2 x 11 maps in Appendix B are not clear and very hard to follow.	
GENERAL	15 ~~7~~	How did the actual leak rates compare to the leak rates that were estimated from listening to the leakage noise? Present numbers.	

MOBILE DIST. OFFICE PROJECT REVIEW COMMENTS	DATE: 8 MAR 95	PAGE 1 of 1
TO: Army Corps of Engineers Omaha District	FROM: (Section): EN-DM (Reviewer): Robert S. Woodruff	
PROJECT: Water Conservation Study LOCATION: Badger A.A.P., Wisconsin	Year:	Line Item No.:
Type of Action: Interim Report		

Item No.	Drawing No. Or Par. No.	COMMENTS	Review Action
16 ~~1.~~	General	E.C.O. 3 deals with shutting-off the fire protection system water supply to the "Caretaker" area buildings. This decision should not be made based on water conservation. The responsible command should make such a decision based on the risks and consequences involved. Based on the data presented in trip report from Mr. Dennis Jones it sounds as if the only purpose of maintaining the process water system is to provide fire protection.	
17 ~~2.~~	General	Doesn't the second paragraph on page 3-12 negate the entire purpose of this study? If the project to connect the treated remediation water to the process water system is already funded doesn't this nullify any savings?	
18 ~~3.~~	General	The process used to quantify the size of the leakage problem seems backwards. The amount of water pumped less the amount used in processing should yield the exact amount of leakage. Basing the size of leaks on the frequency of the sound detected seems speculative. The study on page 2-3 indicates that that the total process water system uses 687,400 gpd. (gallons per day). The process water system leakage is estimated at 194,500 gpd on page 3-5. If there are no processes currently operating where did the other 492,900 gpd end up?	
19 ~~4.~~	Pitometer Assoc. Report	The 1990 report from Pitometer Associates Engineers shows most of the leakage at the hydrants. The Simpson Co. report on the other hand shows most of leakage is in the main piping. This seems to be in conflict.	
20 ~~5.~~	E M C Engineers Calc. Sheet 3 of 5.	The $ 75,000.00 well maintenance budget should be proportioned among the number of pumps not the amount of water pumped. The potable system pumps obviously require more than 2 % of the budget.	
21 ~~6.~~	E M C Engineers Calc. Sheet 1 of 2.	The Leakage Density calculation shown on this sheet doesn't seem very scientific. Variables such as age, material, and type of joints should be taken into account.	

CHAPTER 2

MISSION AND ORGANIZATION

2-1. ORGANIZATION CHART. The structural organization of Badger Army Ammunition Plant is reflected on the chart on page 2-2.

2-2. MISSION. The following mission statement is quoted from AMCCOMR 10-9, Mission of AMCCOM Army Ammunition Plants, dated 17 April 1990.

"Mission - General. The following mission assignments are made to the AAP to be performed under contract operation:

a. Operation and maintenance of active facilities in support of current operations. Maintenance and/or layaway of standby facilities (including machinery and package lines received from industry or other Government installations) in condition to permit rehabilitation and resumption of production within prescribed time limitations.

b. Receipt, surveillance, maintenance, renovation, storage, physical inventory, issue, demilitarization, and salvage of field service stocks, items of industrial stocks and international logistics requirements stocks.

c. Procurement, receipt, storage, and issue of necessary supplies, equipment, components, and essential materials.

d. Industrial readiness planning and emergency mobilization planning, including preparation, review, and revision of prescribed plans.

e. Product assurance functions in support of procurement and production.

f. Production engineering and process engineering.

g. Support services for tenants.

h. Custodial maintenance and administrative functions of subinstallations.

i. Support to and surveillance of Modernization and Expansion Program.

j. Monitor third-party contract efforts performed in accordance with the Plant Utilization Policy.

k. Provide a fire prevention and protection program in compliance with applicable regulations and contract requirements.

Attachment No. 1
(1 of 1)

l. Provide and promote an energy conservation program.

m. Properly manage an environmental program to keep installation in compliance with all Federal, State and local environmental laws, regulations, and rules.

Mission Individual. In addition to general mission responsibilities the following specific assignments are made:

Manufacture propellants and chemical materials (INACTIVE)."

APPENDIX B

FIELD SURVEY NOTES

Field Survey Notes
Data Supplied by BAAP

Field Report for BAAP
EMC #1406-004

16 Oct 94

Talk with Dennis at 20:15. Dennis and I identified the following items we require from BAAP.

1. Asked BAAP for a Mission Statement. They will give to me on 1 November.

2. Ask electric usage data.

    a. Usage and demand kW & kwh
    b. Electrical rates
    c. Run time on motors.
    d. Separate electrical meters on motors?

3. Water use data.

    a. Well pumping information
    b Usage information
    c. Times where theoretically no usage.
    d. Fire hydrant test records.

4. BAAP should explain their three water systems.

5. What are their present leak repair costs/maintenance costs.

6. What are their present water treatment costs.

7. We need well and pump data. Randy will get information on #1.

We set up the following agenda for the next mornings meeting.

Agenda

1. Introduction - pass around attendance sheet.

2. BAAP talk about water system.
   With questions from above.

3. M.E. Simpson should talk about their services.

4. We will recap with discussion on our energy analysis.

What are BAAP's requirements regarding valving off sections of line? Stan may want a schedule

<u>Monday, 17 Oct 94</u>

7:30 a.m. with M.E. Simpson. Mike Simpson thinks water production costs may be on the order of \$0.35 - \$0.55/hour.

9:00 a.m. meeting with M.E. Simpson personnel, members of Olin: William Wolf and Randy Sprecher and COE: Don Hartman. The raw water system used river water for cooling.

Process water system - uses open reservoir. The 6" - 36" pipes have leakage which presently is the entire usage. The process water system is presently not being used for any production.

Potable water system - is only a couple of years old - not part of our survey.

Water system - spiral welded steel pipe 10"-36", rocket area has gray pipe 6", 8", 10".

Now all buildings are shut off at corp stops.

About six years ago Donohue (now Rust) found leaks.

Now Olin says they want to have the potable and process water water system checked .

Olin works four 10's. This is okay with M.E. Simpson.

Gordie Muehe - water systems pipe shop will be conducting water sample test at wells. Cooling water.

10,000 gallons per day for 25 people on potable water.

Plant original used Wisconsin River at 60,000 gpm. In 1970's original wells built or upgraded five wells.

Well #1 - potable water system.
Well #2 -converted to backup on potable.
Well #3 - abandoned, used for ground water monitoring.
Well #4 - high cap system for process water.
Well #5 - 1200 - 1300 gpm back up. Near future project is to convert from oil lube to water

Process water has open reservoirs.

There are prv's serving production area - not in scope.

They have pumping records, electric meter, meters have been tested periodically.

Do they have a production cost? Randy Sprecher says they use a price $0.25/hour.

Pipes that they have cement lined have performed well.

They try to flow hydrants at least once per year. They do water cows from hydrants. They do have hydrants that are very old and parts are no longer available.

Randy Sprecher mentions there is an area he wants checked first, p52 - p58 valves 44, 45, 46. These valves close the rocket area.

Insituform has not been competitive in lining costs.

Randy Sprecher asks for periodic check-in and asks M.E. Simpson to check in on Thursday at 4:00 p.m. M.E. Simpson should check in with Gordie Meuhe.

Arnie Lewis of Olin is the guy's brain to pick. Rocket area presently is "on" and will be checked first.

Intro meeting ended at 10:15 a.m. Everyone in our group proceeds with windshield tour.

Tour

Ball Powder - one of two plants in country - only 12 of 1400 building in operation.

Facility down since 1975.
Randy X287, Bill Wolf X290, Gordie X221

<u>17 Oct 94</u>

12:45 at Bill Wolf's office - drawings and reports.

13:20 at <u>pumphouse #1</u>

Viewing the Altronex control system circular chart readout, shows both system pressure (0 -100 psi) and hydropneumatic tank (level 0-10ft.) - weekly chart.

System pressure varies from 56 psi to 78 psi.
head of tank varies from 2.0' to 3.6'

Installed by CTW Corp. Water Wells and Pump
Waukesha 414 542-4040 and Green Bay 414 866-9044.

Submersible pump - no sizes or information taken. Get information from Randy.

Well #3 - not in use, locked, no keys that fit.

Well #4 - has a time clock set at 5:15 p.m. to 6:15 a.m.
Motor - GE 5k6257XH500A - Model #
Serial # - ENJ525460
HP - 100
rpm 1765
460V
120.3 Amps
Type K frame
C404TP16 B
Class B Code G
Insulation Class F
Max. ambient 40° C

Pump - Layne
33930 - # on nameplate
Vertical centrifugal turbine pump
Layne & Bowler Inc. Memphis, TN

Gauge reads 6 psi and 14' of header

Pressure switch off of pump is Class 9012, Type GNG4, Series A, Range 0-75 Max. allow 240, ADJ units psig

Chlorination unit about 100 gal drum
Duty Master A-C Motor Reliance
Identification Number C48H0502M VE, FR=AB48

Type CS 1 phase
1/4 hp 1725 rpm
115V 5.2A, 60 hz, 135 service factor
40° C ambient insulation Class A

Metering Pump
Series 44-747 Serial # AD35611
Maximum output: 500 gpd
Maximum discharge psig - 125
Wallace and Tiernan
Penwalt Belleview, NJ 07109

[SKETCH]

Well #2

U.S. Electric

HP - 125 phase 3 60 hz
Fram 405TPWPI 460V 144 amp
type Rue
Design B Code F Insulation Class B, 40° C

Well #2 converted 6/9/94 to potable system backup.

Service factor 1.15 1780 rpm

Upper bearing 7222 BAMC
Lower bearing 6212-J
I.D. #B411/V08V203R095R-3
Nominal eff. 95.0
Full low power factor 87.0
Max kVar 23.5

Pump

Fairbanks Morse
Size 11"
7 stages
700 gpm
1750 rpm Model 11M
Serial 7000
Installed 2/93

Power box - main disconnect - set on "off".

Meter on-line reads 206,457 gallons.
Similar set up as well #4.

Double check serial #0316F01
Same chlorinator pump type serial #AG28706
Same chlorinator motor identification #C48H0502M

Well #5

U.S. Electric
200 hp 3 phase 60 hz fr: 445TP
460V 236 amps

Type: Res Design: B Code: G
Insulation Class: B, 60° C continuous
Service factor 1.15
1775 rpm
Upper brg; 7322-M
Lower brg: 6215-J
I.D. #C-6349-11 86-04362 N.R.R.

Pump

Lange - Memphis, TN
83644

Gauge on pump reads 17 psi at 41′ head

[Sketch]

Chlorinator

Same pump serial #AG28697
Motor serial #C48H0502M

16:25 With Dennis and Randy Sprecher

Rocket area is only place they shut down during winter.

Upgrading is not a maintenance project.

There are no "A" lines. Numbering started with "B"

Caretaker Status area

Nitrous Cellulose process lines E and F.
Single Base propellant process lines D and E

Old Acid area - 700 area
1/2 Rocket area - East area only.

Maintained

Ball Powder - Road EE and KK south.

Randy will get a map for us by tomorrow at 13:30.

Dennis got costs from "pipe shop" all they do is fix pipe.
We got spreadsheet with utility data.

18 October 94

At breakfast with Dennis, we review our needs.

- We need electrical consumption of individual wells (from clipboards in well houses).
- Bill marks which pipes have been lined.
- Randy needs chlorine costs.
- Randy - electric rates, peak times, kwh
- Fire hydrant tests data.
- Caretaker map mark-up.

18 Oct 94

13:00 - Meet with Bill Wolf regarding water pipes relined with "cement".

Means cost estimates 10-15% high for here 0276640010
Send Bill Wolf cover sheet for Richardson's.

Bill Wolf really likes concrete lining.
Wolf has a slip lining project $117,000 using PVC pipe. Open each lateral to make connect.
Concrete lining contractors won't come in for jobs under $100,000.

Bill notes there is asbestos cement pipe in the ball powder area.

Bill tells us about a funded project to take the treated water from the remediation area (air stripper/carbon filter) and pump into the process water pipelines. This will enable BAAP to turn off wells 4 and 5. They will pump @ 500 gpm.

The COE has let a job to build another water treatment facility at 3,000 gpm which will be sent to River (Wisconsin).

[Sketch]

Bill thinks the areas need for mobilization. He thinks we could shut off "caretaker areas" and continue some pipes for fire protection.

Bill would like an unofficial rough draft sent to him without COE.

18 Oct 94

14:12 Randy Sprecher

Reading the power bills, Randy explains that the bill is on peak charges.

Randy estimates water cost of $0.25/1000 gallon doesn't include operations and maintenance costs.

Only east rocket is caretaker, not west rocket.

Randy will make a list of D&E areas scheduled for caretaker.

Well 5 is a problem. Mechanically, the well has problems, it also "bucks" the system.

Groundwater treatment plant water line construction in the next 3-6 months.

Conservation club has a submersible pump.

Randy will get data on that well too.

Randy wants a copy of the scope of work. Randy also wants to keep communication lines open. Mentioned differences of opinion with Corps in last few months.

19 Oct 94

Photos of BAAP pumphouse, site and bad pipe.

Randy - exit interview, he didn't have any information I asked for yesterday. I gave him a copy of the COE scope of work and update.

I gave Randy keys to pumphouse.

Head drafter, Bob, has drawings. He also has Microstation drawing.

Bob introduces me and Jeff, and Jeff prepares a disk with BAAP information on it.

Travel to fire station to copy road names and area names from their maps.

Leave site at about 12:20 p.m.

TRIP REPORT

To: Mike Scholz

Fm: Dennis Jones

Dt: 19 October 1994

Re: Field Survey at Badger Army Ammunition Plant

The following are my observations during the field survey on October 17 and 18, 1994.

1. An entrance interview was conducted with personnel on the attached attendance list. Mike Scholz began the meeting by explaining the purpose of the study. We then asked BAAP to describe their water system. There are 3 systems:

   - A Raw water system for supplying cooling water to processes which is currently inactive.

   - A Process water system serves the production buildings and fire hydrants. About 95% of the water use at BAAP is for process water although there are no processes operating. Some water is used for hydrant testing and watering cattle, but the great majority of the water is lost to leaks. Historical data indicates water leaks in the 500,000 to 1,000,000 gallon per day range. Process water is provided by Well #4 which includes a chlorinator. An open reservoir on top of a hill provides storage. Well #4 is manually controlled through use of a time clock to operate at night to maintain the reservoir level. The pressure controls are not used. This pump is required to operate during on-peak electrical rate periods to maintain the reservoir level. Well #5, which has greater capacity will soon replace Well #4 as the primary source as soon as renovation is complete.

   - A Potable water system has recently been installed to serve the administrative and shop areas although process water is still used in these areas to flush toilets and such other uses. The system provides 250 daytime workers with 10,000 gallons of water per day. Well #2 serves this system and includes a large pressure tank and chlorinator. Well #1 was the primary source until about 2 months ago and is now the backup source. About half of the piping on this system is new and the remaining is original. There is significant leaks on this system also which BAAP would like addressed.

Most of the pipe was installed in the 40s. Pipe 10" dia and smaller is typically cast iron and pipe 10" dia and above is typically steel. CI pipes have lead joints which leak when the ground shifts which occurs every spring. Steel pipe is highly corroded and is constantly springing new leaks. BAAP has 3 men full time repairing leaks.

Some pipes have been lined with concrete which is working very well. Ideally BAAP would like to get everything back on line. They are anticipating commercialization, but have no takers yet. Currently most buildings are shut off and only mains necessary to serve hydrants are on the system. Roughly 50% of the mains appear to be filled including most of the major mains. Maps of operating mains or valve position logs are not available.

BAAP provided the following information:

- Monthly water and electric mater data for each well pump

- Water production costs including manpower for operation and repairs, chlorination, and overhead costs.

- Electricity rate information.

- Lists of designated caretaker buildings which are buildings which will never likely be needed and which providing water to is a low priority. There is discussion of not providing fire protection to these buildings except at the perimeter of the area.

- Maps of piping which has been lined with concrete and cost data on concrete lining.

- Cost information on slip-lining. One project is planned to slip-line 1325 feet of 24" pipe with 16" plastic pipe. Cost is estimated at $117,000 which includes 7 lateral connections.

We then took a tour of the facility and saw a 24" pipe section under repair. The pipe resembled a porcupine, it had been repaired so many times. We counted 14 patches along its 15 feet of exposed length. We asked why don't they replace the whole section to which they replied, "Where would we stop? The whole pipe looks like that."

The Rocket area is shut of seasonally. Analysis of data may provide separate leak rate for this area.

The above comments include comments made in later conversations.

Thinking about the project:

1. It seems that caretaker areas should be abandoned, have hydrants on the perimeter to contain a fire.

2. Alternatives include the following:

    - We could look at relining large mains and replacing small mains, but probably not laterals to buildings. Leaking valves and hydrants should be replaced. Savings would come in water production and possibly from lower repair costs, although

repairs are currently performed by a single 3 man crew which could not likely be eliminated. There must be some repair capability.

- We could recommend a more aggressive and organized pipe repair program combining annual leak detection surveys and systematic lining/replacement of mains on a pipe condition/process priority basis. Purchase of leak detection equipment is a possibility. Currently the only indication of a leak is when it bubbles up out of the ground.

- We could lower operating pressure to reduce leak rates?

- Pipes should not be patched, but rather replaced in 20 foot lengths at an estimated cost of $ per length for a life cycle cost of $. Each 20 foot length must be patched every 2.3 years at a cost of $ for a life cycle cost of $. At the rate the system is currently springing leaks you could have the whole system replaced in 15 years.

E M C Engineers, Inc.
Badger Army Ammunition Plant
EMC #1406-004

Historical Electrical and
Water Meter Data

Prepared by: T Poeling
4/12/95
Checked by: ________

Date	Water Pumped - Well #1	Water Pumped - Well #2	Water Pumped - Well #4	Process Water Pumped Wells #2, #4	Amount Required of Wells - IRM Pumps 500 gpm
Jan-92	515,300	15,100	22,527,765	22,542,865	582,865
Feb-92	351,950	4,800	21,937,465	21,942,265	0
Mar-92	387,300	6,072,900	20,428,675	26,501,575	4,541,575
Apr-92	377,525	12,324,550	15,047,300	27,371,850	5,411,850
May-92	420,675	13,290,750	13,780,680	27,071,430	5,111,430
Jun-92	457,800	12,309,000	15,073,470	27,382,470	5,422,470
Jul-92	680,400	8,124,650	11,666,134	19,790,784	0
Aug-92	381,100	8,500,450	13,368,286	21,868,736	0
Sep-92	341,300	5,525,900	10,714,310	16,240,210	0
Oct-92	345,975	8,477,200	11,246,800	19,724,000	0
Nov-92	319,025	7,175,500	10,984,090	18,159,590	0
Dec-92	343,175	5,078,775	11,891,715	16,970,490	0
Tot/Avg	4,921,525	86,899,575	178,666,690	265,566,265	21,070,190
Jan-93	350,525	6,351,725	10,525,815	16,877,540	0
Feb-93	274,400	7,451,700	8,510,140	15,961,840	0
Mar-93	324,000	1,447,500	21,958,020	23,405,520	1,445,520
Apr-93	320,250	0	20,523,390	20,523,390	0
May-93	327,350	12,600	17,480,650	17,493,250	0
Jun-93	364,000	4,317,500	15,739,770	20,057,270	0
Jul-93	400,750	5,332,775	12,848,505	18,181,280	0
Aug-93	392,250	8,591,825	11,793,225	20,385,050	0
Sep-93	403,200	10,517,450	8,790,177	19,307,627	0
Oct-93	465,000	7,941,050	11,659,143	19,600,193	0
Nov-93	448,000	8,212,500	11,414,710	19,627,210	0
Dec-93	454,300	11,461,900	12,214,920	23,676,820	1,716,820
Tot/Avg	4,524,025	71,638,525	163,458,465	235,096,990	3,162,340
Jan-94	565,200	10,522,900	13,476,950	23,999,850	2,039,850
Feb-94	460,400	9,591,800	13,963,600	23,555,400	1,595,400
Mar-94	535,325	11,670,700	17,886,937	29,557,637	7,597,637
Apr-94	464,525	9,415,900	12,890,008	22,305,908	345,908
May-94	489,550	10,910,200	9,502,115	20,412,315	0
Jun-94	515,132	2,722,800	15,241,336	17,964,136	0
Jul-94	517,568	60,500	19,535,234	19,595,734	0
Aug-94	527,600	0	17,157,320	17,157,320	0
Sep-94	440,775	0	14,486,550	14,486,550	0
Tot/Avg	4,516,075	54,894,800	134,140,050	189,034,850	0
Year Trend	6,021,433	73,193,067	178,853,400	252,046,467	11,578,795
3 Yr. Avg.	5,155,661	77,243,722	173,659,518	250,903,241	11,937,108

E M C Engineers, Inc.
Badger Army Ammunition Plant
EMC #1406-004

Historical Electrical and
Water Meter Data

Prepared by: T Poeling
4/12/95
Checked by: ________

Date	Electricity Consumed	On Peak Consumption	Off Peak Consumption	On Peak Demand	Off Peak Demand	Cost	Cost per kWh	Demand Charge
Jan-92	444,000	190,166	253,834	1,128	792	$17,807	$0.0401	$7,287
Feb-92	464,000	191,692	272,308	800	720	$16,070	$0.0346	$5,186
Mar-92	408,000	172,112	235,888	768	776	$14,521	$0.0356	$4,961
Apr-92	392,000	163,712	228,288	1,000	1,120	$15,588	$0.0398	$6,460
May-92	448,000	188,484	259,516	1,248	1,392	$18,391	$0.0411	$8,062
Jun-92	532,000	234,908	297,092	1,552	1,616	$22,243	$0.0418	$10,026
Jul-92	276,000	122,182	153,818	648	680	$11,027	$0.0400	$4,186
Aug-92	276,000	109,754	166,246	600	672	$10,564	$0.0383	$3,876
Sep-92	244,000	101,716	142,284	560	536	$9,736	$0.0399	$3,618
Oct-92	296,000	122,556	173,444	640	632	$11,337	$0.0383	$4,134
Nov-92	400,000	157,248	242,752	752	656	$14,211	$0.0355	$4,858
Dec-92	412,000	153,472	258,528	680	672	$13,713	$0.0333	$4,210
Tot/Avg	4,592,000	1,908,002	2,683,998	865	855	$175,208	$0.0382	$66,865
Jan-93	340,000	134,790	205,210	640	680	$12,148	$0.0357	$4,134
Feb-93	360,000	148,192	211,808	664	704	$12,754	$0.0354	$4,289
Mar-93	344,000	145,960	198,040	728	656	$12,871	$0.0374	$4,703
Apr-93	300,000	133,504	166,496	632	536	$11,375	$0.0379	$4,083
May-93	268,000	113,654	154,346	568	480	$10,255	$0.0383	$3,669
Jun-93	236,000	110,426	125,574	592	528	$9,555	$0.0405	$3,824
Jul-93	228,000	95,220	132,780	568	680	$9,149	$0.0401	$3,669
Aug-93	260,000	108,704	151,296	520	486	$8,508	$0.0327	$3,359
Sep-93	228,000	93,576	134,424	560	496	$9,127	$0.0400	$3,618
Oct-93	276,000	105,550	170,450	584	576	$9,150	$0.0332	$3,947
Nov-93	340,000	133,308	206,692	624	672	$11,639	$0.0342	$4,256
Dec-93	388,000	145,274	242,726	632	712	$12,575	$0.0324	$4,310
Tot/Avg	3,568,000	1,468,158	2,099,842	609	601	$129,106	$0.0365	$47,862
Jan-94	408,000	165,978	242,022	712	800	$13,640	$0.0334	$4,856
Feb-94	408,000	164,512	243,488	704	792	$13,573	$0.0333	$4,801
Mar-94	348,000	136,142	211,858	712	720	$12,415	$0.0357	$4,856
Apr-94	316,000	122,326	193,674	584	608	$10,906	$0.0345	$3,983
May-94	240,000	95,446	144,554	496	560	$8,845	$0.0369	$3,383
Jun-94	236,000	105,308	130,692	560	488	$11,201	$0.0475	$3,819
Jul-94	228,000	100,434	127,566	568	446	$9,182	$0.0403	$3,874
Aug-94	260,000	114,608	145,392	568	464	$9,821	$0.0378	$3,874
Sep-94	224,000	103,268	120,732	504	488	$8,704	$0.0389	$3,437
Tot/Avg	2,668,000	1,108,022	1,559,978	601	596	$98,285	$0.0376	$36,883
Year Trend	3,557,333	1,477,363	2,079,971	601	596	$131,047	$0.0376	$49,177
3 Yr. Avg.	3,905,778	1,617,841	2,287,937	692	684	$145,120	$0.0374	$54,635

MONTHLY COMPARISON OF UTILITIES CY1992

		January 1992	February 1992	March 1992	April 1992	May 1992	June 1992	July 1992	August 1992	September 1992	October 1992	November 1992	December 1992	1992 AVERAGE* or TOTAL	
ELECTRICITY															
Electricity Consumed	kwh	444,000	464,000	408,000	392,000	448,000	532,000	276,000	276,000	244,000	246,000	400,000	412,000	4,592,000	
On Peak Consumption	kwh	190,166	191,692	172,112	163,712	188,484	234,908	122,182	109,754	101,716	122,556	157,248	153,472	1,908,002	
Off Peak Consumption	kwh	253,834	272,308	235,888	228,288	259,516	297,092	153,818	166,246	142,284	173,444	242,752	258,528	2,683,998	
Cost	$	17,807.62	16,069.78	14,521.13	15,588.32	18,390.63	22,242.59	11,027.21	10,563.84	9,735.87	11,336.73	14,211.13	13,712.50	175,207.35	
Cost per kwh	¢	0.040107	0.034633	0.035591	0.039766	0.041051	0.041809	0.039954	0.038275	0.039901	0.038300	0.035528	0.033283	0.038155	*
On Peak Demand	kw	1,128	800	768	1,000	1,248	1,552	648	600	560	640	752	680	865	*
Off Peak Demand	kw	792	720	776	1,120	1,392	1,616	680	672	536	632	656	672	855	*
Power Factor	%	100.00	100.00	100.00	100.00	98.99	97.55	99.99	100.00	100.00	100.00	99.68	100.00	99.77	*
Load Factor	%	58.57	75.52	76.33	54.44	46.74	49.25	59.16	59.90	62.60	62.17	67.16	74.25	62.17	*
Avg. Hourly Consumption	kwh	661	604	586	544	583	764	383	359	351	398	505	505	520	*
Demand Charge	$	7,286.88	5,168.00	4,961.28	6,460.00	8,062.08	10,025.92	4,186.08	3,876.00	3,617.60	4,134.40	4,857.92	4,210.48	66,846.64	
STEAM															
Steam Generated	lbs	4,105,000	4,033,967	3,114,000	2,173,500	4,073,436	4,776,226	-0-	-0-	281,000	1,269,000	3,344,064	4,188,000	31,358,193	
Steam to Area	lbs	3,899,750	3,791,929	2,896,020	2,021,355	3,869,765	4,537,415	-0-	-0-	269,760	1,218,240	3,143,420	3,894,840	29,542,494	
No. 2 Oil Burned	gal	85	2,507	105	2,793	30,525	38,497	-0-	-0-	-0-	105	1,848	-0-	76,465	
No. 6 Oil Burned	gal	-0-	-0-	-0-	-0-	-0-	-0-	-0-	-0-	-0-	-0-	-0-	-0-	-0-	
Degree Days		1,291	1,073	976	653	222	69	31	76	193	551	499	1,346	7,480	
Avg. Monthly Temperature	°F	23.4	28.0	33.5	43.3	59.4	66.4	67.1	65.1	59.7	47.3	31.7	21.6	45.5	*
Steam Generated/gal	lbs	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	*
Natural Gas Consumption	therms	46,928	45,752	38,246	22,736	8,822	1,737	-0-	-0-	2,996	9,532	46,562	50,778	274,089	
Natural Gas Cost	$	13,630.28	14,371.02	15,600.36	4,678.32	2,381.76	1,174.05	650.00	650.00	1,617.11	4,188.28	14,795.54	13,548.33	92,285.05	
PLANT AIR P.H. #1															
Free Air Compressed	cu ft	302,436	312,192	282,924	258,534	112,194	169,917	65,040	69,105	69,105	195,933	273,168	341,460	2,452,008	
Compressor Operation	hrs	744	768	696	636	276	418	160	170	170	482	672	840	6,032	
WATER															
Water Pumped from Well #1	gal	515,300	351,950	387,300	377,525	420,675	457,800	680,400	381,100	341,300	345,975	319,025	343,175	4,921,525	
Water Pumped from Well #2	gal	15,100	4,800	6,072,900	12,324,550	13,290,750	12,309,000	8,124,650	8,500,450	5,525,900	8,477,200	7,175,500	5,078,775	86,899,575	
Water Pumped from Well #4	gal	22,527,765	21,937,465	20,428,675	15,047,300	13,780,680	15,073,470	11,666,134	13,368,286	10,714,310	11,246,800	10,984,090	11,891,715	178,666,690	
Water Pumped from Well #5	gal	-0-	-0-	-0-	-0-	-0-	-0-	-0-	-0-	-0-	-0-	-0-	-0-	-0-	
Treated Water to Area	gal	23,058,165	22,294,215	26,888,875	27,749,375	27,492,105	27,840,270	20,471,184	22,249,836	16,581,510	20,069,975	18,478,615	17,313,665	270,487,790	
WASTEWATER & SEWAGE															
Wastewater	gal	20,937,000	20,257,000	24,374,000	25,133,000	24,691,000	25,030,000	18,320,000	19,864,000	14,834,000	18,172,000	16,799,000	15,793,000	244,204,000	
Sewage Treatment Flow	gal	479,000	1,945,600	1,315,000	495,000	298,000	977,000	942,500	295,000	528,000	742,000	1,285,000	1,330,000	9,931,500	
Ind. W.W. Treatment Flow	gal	6,778,100	7,267,350	6,193,450	7,038,420	5,928,100	6,176,100	5,553,500	4,852,700	5,034,300	4,434,625	5,720,175	5,245,700	70,222,520	

MONTHLY COMPARISON OF UTILITIES CY1993

			1	2	3	4	5	6	7	8	9	10	11	12	13	
			January 1993	February 1993	March 1993	April 1993	May 1993	June 1993	July 1993	August 1993	September 1993	October 1993	November 1993	December 1993	1993 AVERAGE * or TOTAL	
	ELECTRICITY															
1	Electricity Consumed	kwh	340,000	360,000	344,000	300,000	268,000	236,000	228,000	260,000	228,000	276,000	340,000	388,000	3,568,000	
2	On Peak Consumption	kwh	134,790	148,192	145,960	133,504	113,654	110,426	95,220	108,704	93,576	105,550	133,508	145,274	1,468,158	
3	Off Peak Consumption	kwh	205,210	211,808	198,040	166,496	154,346	125,574	132,780	151,296	134,424	170,450	206,692	242,726	2,099,842	
4	Cost	$	12,147.53	12,753.90	12,870.67	11,375.38	10,254.97	9,554.94	9,149.08	8,508.04*	9,127.28	9,150.86*	11,639.13	12,574.79	129,105.92	
5	Cost per kwh	¢	0.035728	0.035428	0.037415	0.037918	0.038265	0.040487	0.040128	0.032723	0.040032	0.033153	0.034233	0.032409	0.036184	*
6	On Peak Demand	kw	640	664	728	632	568	592	568	520	560	584	624	632	609	*
7	Off Peak Demand	kw	680	704	656	536	480	528	680	496	496	576	672	712	601	*
8	Power Factor	%	100.00	100.00	99.99	100.00	99.99	100.00	100.00	99.99	98.19	95.27	100.00	100.00	99.45	*
9	Load Factor	%	79.06	77.90	67.89	63.20	59.57	57.28	57.67	63.13	56.55	63.52	73.24	77.52	66.79	*
10	Avg. Hourly Consumption	kwh	506	517	494	431	338	339	328	328	317	371	457	490	410	*
11	Demand Charge	$	4,134.40	4,289.44	4,702.88	4,082.72	3,669.28	3,824.32	3,669.28	3,559.20	3,617.60	3,947.29	4,255.68	4,310.24	47,862.33	
12																
13	STEAM															
14	Steam Generated	lbs	3,749,000	3,388,000	3,132,000	2,112,000	345,000	49,000	-0-	-0-	385,000	1,133,000	2,546,000	4,089,000	20,928,000	
15	Steam to Area	lbs	3,486,570	3,150,840	2,912,760	1,964,160	320,850	46,060	-0-	-0-	365,750	1,065,020	2,367,780	2,989,080	18,668,870	
16	No. 2 Oil Burned	gal	1,979	-0-	1,575	-0-	84	-0-	-0-	-0-	-0-	-0-	-0-	-0-	3,638	
17	No. 6 Oil Burned	gal	-0-	-0-	-0-	-0-	-0-	-0-	-0-	-0-	-0-	-0-	-0-	-0-	-0-	
18	Degree Days		1,412	1,274	1,076	666	224	75	1	11	284	567	950	1,258	7,798	
19	Avg. Monthly Temperature	°F	19.5	19.6	30.3	42.8	58.7	65.9	71.6	71.7	55.8	46.9	33.4	24.4	45.05	*
20	Steam Generated/gal	lbs	118.2	N/A	118.7	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	118.45	*
21	Natural Gas Consumption	therms	44,115	43,928	36,523	26,244	4,770	676	-0-	-0-	4,739	14,531	33,665	53,413	262,604	
22	Natural Gas Cost	$	14,280.92	13,384.12	11,361.93	8,398.03	2,311.69	872.43	650.00	650.00	2,171.38	5,401.29	11,504.91	18,306.26	89,292.96	
23																
24	PLANT AIR P.H. #1															
25	Free Air Compressed	cu ft	273,168	273,168	292,680	311,379	60,975	69,105	65,040	69,105	65,040	69,105	230,892	331,704	2,111,361	
26	Compressor Operation	hrs	672	672	720	766	150	170	160	170	160	170	568	816	5,194	
27																
28	WATER															
29	Water Pumped from Well #1	gal	350,525	274,400	324,000	320,250	327,350	364,000	400,750	392,250	403,200	465,000	448,000	454,300	4,524,025	
30	Water Pumped from Well #2	gal	6,351,725	7,451,700	1,447,500	-0-	12,600	4,317,500	5,332,775	8,591,825	10,517,450	7,941,050	8,212,500	11,461,900	71,638,525	
31	Water Pumped from Well #4	gal	10,525,815	8,510,140	21,958,020	20,523,390	17,480,650	15,739,770	12,848,505	11,793,225	8,790,177	11,659,143	11,414,710	12,214,920	163,458,465	
32	Water Pumped from Well #5	gal	-0-	-0-	-0-	-0-	-0-	-0-	-0-	-0-	-0-	-0-	-0-	-0-	-0-	
33	Treated Water to Area	gal	17,228,065	16,236,240	23,729,520	20,843,640	17,820,600	20,421,270	18,582,030	20,777,300	19,710,827	20,065,193	20,075,210	24,131,120	239,621,015	
34																
35	WASTEWATER & SEWAGE															
35	Wastewater	gal	15,674,000	14,781,000	21,537,000	18,950,000	16,001,000	18,309,000	16,696,000	18,659,000	17,713,000	18,100,000	18,210,000	21,922,000	216,552,000	
37	Sewage Treatment Flow	gal	1,055,000	938,000	3,335,000	898,000	315,500	28,500	934,000	202,500	62,000	71,500	208,500	730,000	8,778,500	
33	Ind. W.W. Treatment Flow	gal	4,764,700	4,007,300	9,084,700	6,868,162	5,717,250	5,457,800	7,726,800	6,243,000	4,613,023	4,693,675	5,015,100	4,450,108	68,641,618	
39									* Includes		* Includes					
40									$1,000.00 rebate		$1,000.00 rebate					

MONTHLY COMPARISON OF UTILITIES CY1994

		January 1994	February 1994	March 1994	April 1994	May 1994	June 1994	July 1994	August 1994	September 1994	October 1994	November 1994	December 1994	1994 AVERAGE * or TOTAL
ELECTRICITY														
Electricity Consumed	kwh	408,000	408,000	348,000	316,000	240,000	236,000	228,000	260,000	224,000				
On Peak Consumption	kwh	165978	164,512	136,142	122,326	95,446	105,308	100,434	114,608	103,268				
Off Peak Consumption	kwh	242,022	243,468	211,858	193,674	144,554	130,692	127,566	145,392	120,732				
Cost	$	13,639.89	13,573.13	12,414.72	10,905.78	8,844.54	11,201.06	9,181.70	9,820.66	8,703.67				
Cost per kwh	¢	0.033431	0.033267	0.035674	0.034512	0.036852	0.047462	0.040271	0.037772	0.038856				*
On Peak Demand	kw	712	704	712	584	496	560	568	568	504				*
Off Peak Demand	kw	800	792	720	608	560	488	446	464	488				*
Power Factor	%	100.00	100.00	100.00	100.00	100.00	99.87	100.00	100.00	100.00				*
Load Factor	%	82.33	83.27	70.22	70.46	69.52	60.55	57.67	57.79	61.73				*
Avg. Hourly Consumption	kwh	586	586	500	411	345	339	328	328	311				*
Demand Charge	$	4,855.84	4,801.28	4,855.84	3,982.88	3,382.72	3,819.20	3,873.76	3,873.76	3,437.28				
STEAM														
Steam Generated	lbs	4,782,000	4,429,000	3,492,000	891,000	229,000	-0-	-0-	-0-	139,000				
Steam to Area	lbs	3,626,640	3,302,000	2,633,760	828,000	215,260	-0-	-0-	-0-	136,000				
No 2 Oil Burned	gal	7,698	5,346	71	-0-	40	-0-	-0-	-0-	-0-				
No 6 Oil Burned	gal	-0-	-0-	-0-	-0-	-0-	-0-	-0-	-0-	-0-				
Degree Days		1,823	1,424	958	549	216	33	13	56	95				
Avg. Monthly Temperature	°F	62	14.2	34.1	49.1	59.0	70.6	70.3	66.8	64.6				*
Steam Generated/Gal	lbs	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A				*
Natural Gas Consumption	therms	49,719	51,403	40,468	11,253	3,079	5	-0-	-0-	1,404				
Natural Gas Cost	$	17,707.75	18,934.61	14,149.72	4,033.71	1,562.78	651.52	650.00	650.00	1,182.53				
PLANT AIR P.H. #1														
Free Air Compressed	cu ft	273,168	273,168	302,436	273,981	65,040	69,105	60,975	77,235	69,105				
Compressor Operation	hrs	672	672	744	674	160	170	150	190	170				
WATER														
Water Pumped from Well #1	gal	565,200	460,400	535,325	464,525	489,550	515,132	517,568	527,600	440,775				
Water Pumped from Well #2	gal	10,522,900	9,591,800	11,670,700	9,415,900	10,910,200	2,722,800	60,500	-0-	-0-				
Water Pumped from Well #4	gal	13,476,950	13,963,600	17,886,937	12,890,008	9,502,115	15,241,336	19,535,234	17,157,320	14,486,550				
Water Pumped from Well #5	gal	-0-	-0-	-0-	-0-	-0-	-0-	-0-	-0-	-0-				
Treated Water to Area	gal	24,565,050	24,015,800	30,092,962	22,770,433	20,901,865	18,479,268	20,113,302	17,684,920	14,927,325				
WASTEWATER & SEWAGE														
Wastewater	gal	22,007,000	21,782,000	27,270,000	20,661,000	18,678,000	16,479,000	17,987,000	15,788,000	13,350,000				
Sewage Treatment Flow	gal	840,000	1,985,000	1,450,000	42,500	35,600	137,100	122,000	164,500	259,000				
Ind. W.W. Treatment Flow	gal	4,224,950	3,242,500	9,476,300	7,219,058	7,252,550	7,897,648	7,905,664	6,597,200	4,446,230				

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Table No. 6 summarizes the approximate quantities of existing water distribution piping.

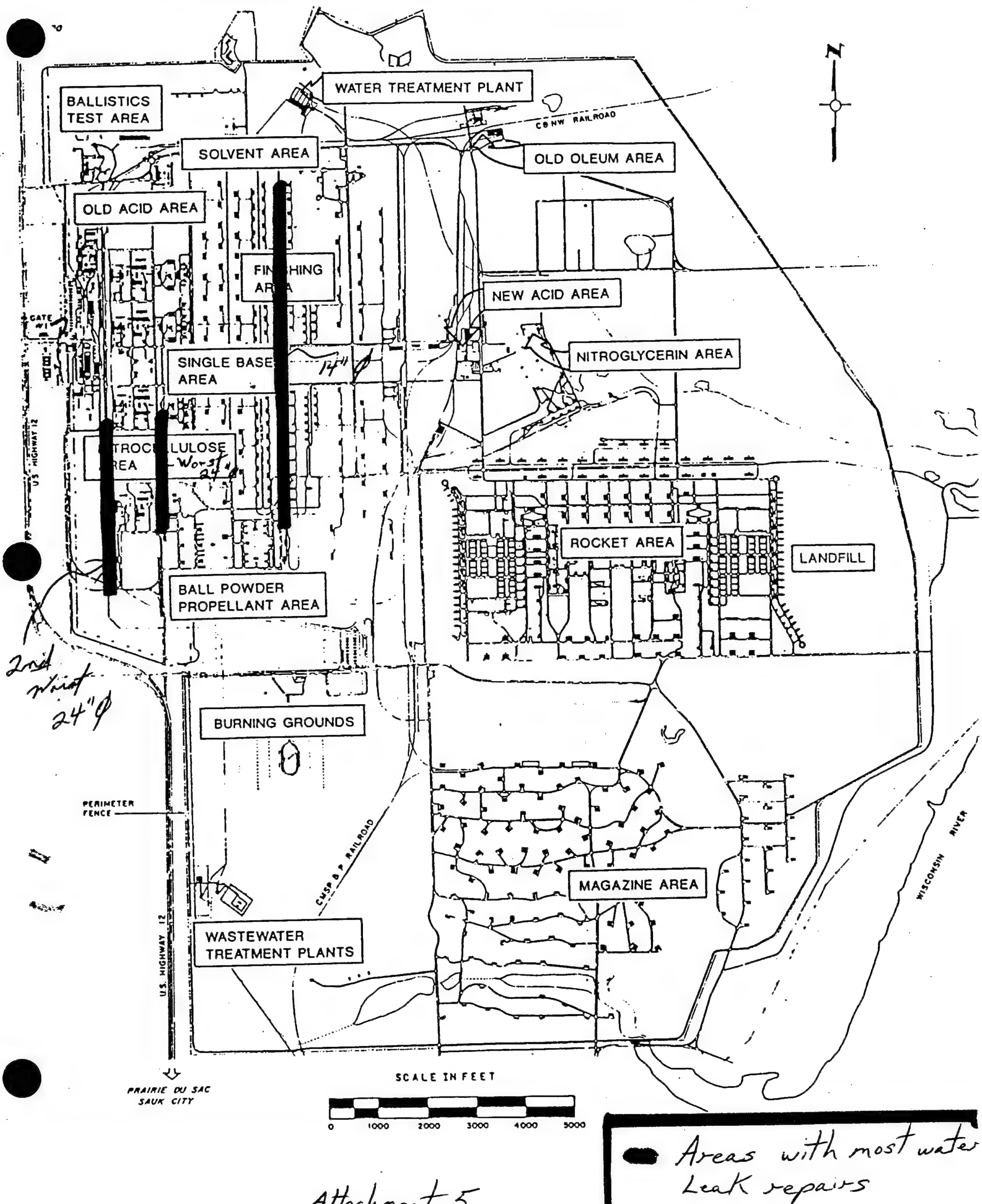
TABLE NO. 6
SUMMARY OF WATER DISTRIBUTION PIPING
BADGER ARMY AMMUNITIONS PLANT
BARABOO, WISCONSIN

Pipe Size (inch)	Unfiltered and Filtered Water (L.F.)	Recovered Water (L.F.)
1	22,350	
1-1/4	2,850	
1-1/2	24,800	
2	28,400	
2-1/2	5,300	
3	10,600	
4	8,300	3,400
6	116,000	5,400
8	56,800	1,500
10	60,400	2,500
12	75,800	11,600
14	19,100	5,000
16	78,800	1,900
20		40
24	81,700	200
30	13,000	10,560
36	10,800	5,300
58		18,750
TOTALS:	615,000 L.F. 116.5 MILES	66,150 L.F. 12.5 MILES

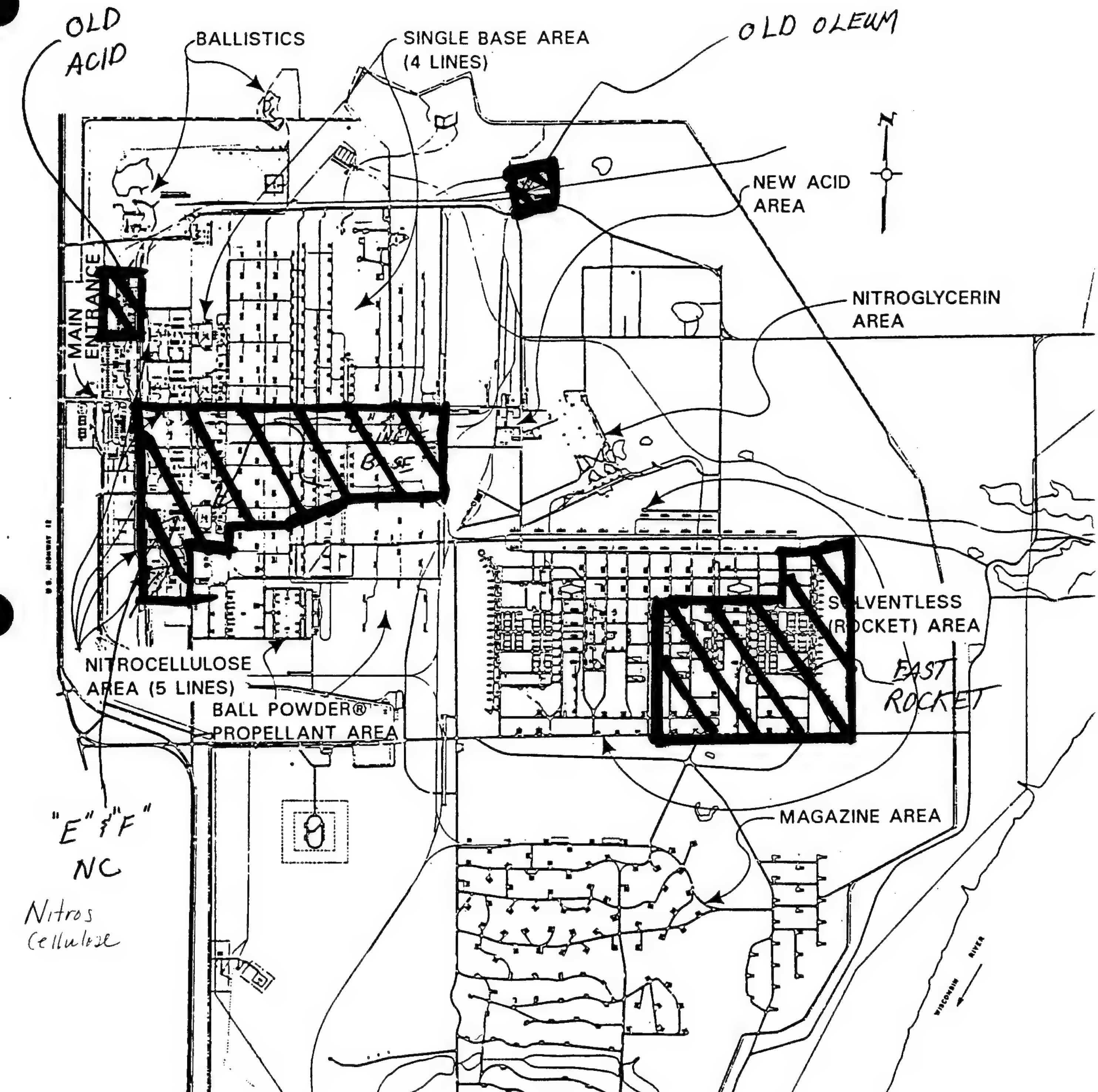
The distribution system also includes approximately 450 valves and 675 fire hydrants located throughout the distribution system.

From 1989 Wells Engineers, Inc.
BAAP Water System Analysis
65% Report

Badger Army Ammunition Plant



Attachment 5



☐ MODIFIED CARETAKER

12/14/94	BUILDING NUMBER	REAL PROP NO.	AREA NO.	MODIFIED CARETAKER ACCOUNT DESCRIPTION
Area 01	000A-01	1671	01	Steam Pressure Reducing Station
ld Oleum	0231-01	227	01	Oleum Pumper House
ld Acid	0420-05	291	01	Waste Acid Disposal Plant
	0700-01	331	01	Compressor House
	0701-00	333	01	Ammonia Storage
	0702-00	334	01	Oxidation House
	0703-00	335	01	Nitric Acid Concentrator
	0704-01	336	01	Sulfuric Acid Concentrator
	0704-02	337	01	Sulfuric Acid Concentrator
	0704-03	338	01	Sulfuric Acid Concentrator
	0705-00	339	01	Weak Nitric Circulator
	0706-00	340	01	Strong Nitric Circulator
	0707-00	341	01	Acid Weigh House (Main Bldg. destroyed)
	0708-00	342	01	Denitrated Sulfuric Storage
	0709-00	343	01	Pyro Spent Storage
	0710-00	344	01	Concentrated Mix Storage
	0711-01	345	01	Sulfuric Acid Storage
	0711-02	346	01	Sulfuric Acid Storage
	0712-01	347	01	Unloading Station
	0712-02	348	01	Unloading Station
	0712-03	349	01	Unloading Station
	0712-04	350	01	Unloading Station
	0712-05	351	01	Unloading Station
	0712-06	352	01	Unloading Station
	0712-07	353	01	Unloading Station
	0712-08	354	01	Unloading Station
	0712-13	355	01	Unloading Station
	0712-14	356	01	Unloading Station
	0712-15	357	01	Unloading Station
	0712-16	358	01	Unloading Station
	0712-22	363A	01	Unloading Station
	0712-23	363B	01	Unloading Station
	0712-24	363C	01	Unloading Station
	0713-00	364	01	Ammonia Compressor House
	0714-00	365	01	Spare Parts Storehouse
	0715-00	366	01	Car Warming Shed
	0718-00	367	01	Acid Line Office
	0719-01	368	01	Acid Area Shop
	0719-02	369	01	Oleum Area Shop
	0720-01	370	01	Change House
	0720-02	371	01	Change House
	0722-01	372	01	Oleum Storage
	0722-02	373	01	Oleum Storage
	0723-00	374	01	Mixed Acid Storage
	0728-02	375	01	Oleum Manufacturing Plant
	0730-00	376	01	Nitric Acid Recovery
	0731-00	377	01	Acid Brick Storage
	0734-02	378	01	Anti-freeze Storage
	0735-00	379	01	NGMA Storage

12/14/94	BUILDING NUMBER	REAL PROP NO.	AREA NO.	MODIFIED CARETAKER ACCOUNT DESCRIPTION
Area 03	0014-00	1759	03	Steam Pressure Reducing Station
ld NG	0506-00	303	03	Oil Store
	6513-03	1068	03	Latrine
	6651-00	1166	03	Mixed Acid Lines
	6652-00	1167	03	Mixed Acid Weigh House & Storage
	6654-00	1169	03	Mixed Acid Unloading
	6655-00	1170	03	Semi-mixed Acid Loading
	6656-02	1172	03	Glycerin Pump & Heater House
	6657-02	1174	03	NG Nitrating & Separating House
	6659-02	1177	03	Outside Catch Tank
	6660-00	1178	03	Refrigerating House
	6661-00	1179	03	Brine Storage Tank
	6662-00	1180	03	Brine Lines
	6666-00	1184	03	Spent Acid Lines
	6667-02	1186	03	NG Neutralizing House
	6668-02	1188	03	Outside Catch Tank & Slum House
	6668-04	1190	03	Outside Catch Tank & Slum House
	6671-00	1192	03	Con-mix Unloading Station
	6672-02	1194	03	NG Storehouse
	6675-00	1197	03	Compressor House
	6676-02	1199	03	Soda Ash Storehouse
	6677-00	1200	03	NG Transfer House
ea 08	000E-01	1712	08	Steam Pressure Reducing Station
-line NC	000E-02	1713	08	Steam Pressure Reducing Station
	0420-04	290	08	Waste Acid Disposal Plant
	0712-20	362	08	Unloading Station
	5000-00	1000	08	Cellulose Warehouse
	5002-00	1001	08	Acid Mix & Weigh House
	5003-00	1002	08	Spent, OV & MF Acid Storage
	5005-00	1003	08	Mixed Acid Storage
	5007-00	1004	08	Acid Screening House
	5008-00	1005	08	Acid Heat & Circulator House
	5010-00	1007	08	Cellulose Drying House & Conveyor
	5011-00	1008	08	Emergency Catch House
	5012-00	1009	08	Nitrating House
	5013-00	1010	08	Fume Exhaust Pump House
	5014-00	1011	08	NC Pump House
	5015-00	1012	08	E-line Office
	5016-00	1013	08	Change House
	5017-00	1014	08	Flume Line
	5019-00	1015	08	Boiling Tub House
	5020-00	1016	08	Boiling Tub Settling Pit
	5022-00	1017	08	Beater House
	5024-00	1018	08	Poacher & Blender House
	5025-00	1019	08	Poacher & Blender Settling Pit
	5026-00	1020	08	Final Wringer House
	5030-00	1021	08	E-line Office
	5031-00	1022	08	Change House
	5035-00	1023	08	Spent Acid Pump House

12/14/94	BUILDING NUMBER	REAL PROP NO.	AREA NO.	MODIFIED CARETAKER ACCOUNT DESCRIPTION
	5036-00	1024	08	Change House
	5037-00	1025	08	E-line Shop
	5038-00	1026	08	Chemical Storehouse
	5043-00	1027	08	Final Wringer Receiving House
	5044-00	1028	08	Cellulose Drying House & Conveyor
	5045-00	1029	08	Maintenance Parts Storehouse
	5046-00	1030	08	Constant Level Water Tank
Area 09	000F-01	1715	09	Steam Pressure Reducing Station
F-line NC	000F-02	1716	09	Steam Pressure Reducing Station
	0420-06	292	09	Waste Acid Disposal Plant
	0712-21	363	09	Unloading Station
	9000-00	1572	09	Cellulose Warehouse
	9002-00	1574	09	Acid Mix & Weigh House
	9003-00	1575	09	Spent, OV & MF Acid Storage
	9005-00	1576	09	Mixed Acid Storage
	9007-00	1577	09	Acid Screening House
	9008-00	1578	09	Acid Heat & Circulator House
	9010-00	1580	09	Cellulose Drying House & Conveyor
	9011-00	1581	09	Emergency Catch House
	9012-00	1582	09	Nitrating House
	9013-00	1583	09	Fume Exhaust Pump House
	9014-00	1584	09	NC Pump House
	9016-01	1586	09	Change House
	9016-02	1587	09	Change House
	9016-03	1588	09	Change House
	9017-00	1589	09	Flume Line
	9019-00	1590	09	Boiling Tub House
	9020-00	1591	09	Boiling Tub Settling Pit
	9022-00	1592	09	Beater House
	9024-00	1593	09	Poacher & Blender House
	9025-00	1594	09	Poacher & Blender Settling Pit
	9026-00	1595	09	Final Wringer House
	9030-00	1596	09	F-line Office
	9035-00	1597	09	Spent Acid Pump House
	9037-00	1598	09	F-line Shop
	9038-00	1599	09	Chemical Storehouse
	9043-00	1600	09	Final Wringer Receiving House
	9045-00	1601	09	Maintenance Parts Storehouse
	9046-00	1602	09	Constant Level Water Tank
Area 11	1800-02	621	11	Glaze House
C-line SB	1800-03	622	11	Glaze House
	1850-01	635	11	Screening House
	1850-02	636	11	Screening House
	1850-03	637	11	Screening House
	1850-04	638	11	Screening House
	1852-02	646	11	Screen Storehouse
	1852-04	648	11	Screen Storehouse

12/14/94	BUILDING NUMBER	REAL PROP NO.	AREA NO.	MODIFIED CARETAKER ACCOUNT DESCRIPTION
Area 12	000D-03	1706	12	Steam Pressure Reducing Station
·line SB	000D-04	1707	12	Steam Pressure Reducing Station
	0923-03	459	12	Telpher system
	1600-19	501	12	Solvent Recovery House
	1600-20	502	12	Solvent Recovery House
	1600-21	503	12	Solvent Recovery House
	1600-22	504	12	Solvent Recovery House
	1600-23	505	12	Solvent Recovery House
	1600-24	506	12	Solvent Recovery House
	1600-25	507	12	Solvent Recovery House
	1600-26	508	12	Solvent Recovery House
	1600-27	509	12	Solvent Recovery House
	1650-20	544	12	Water Dry House
	1650-21	545	12	Water Dry House
	1650-22	546	12	Water Dry House
	1650-23	547	12	Water Dry House
	1650-24	548	12	Water Dry House
	1650-25	549	12	Water Dry House
	1650-26	550	12	Water Dry House
	1725-08	586	12	Air Dry House
	1750-13	608	12	Rest House
	1750-17	612	12	Rest House
	1750-18	613	12	Rest House
	1800-04	623	12	Glaze House
	1800-05	624	12	Glaze House
	1800-06	625	12	Glaze House
	1850-05	639	12	Screening House
	1850-06	640	12	Screening House
	1850-07	641	12	Screening House
	1850-08	642	12	Screening House
	1852-05	649	12	Screen Storehouse
	1975-04	764	12	Powder Line Office
	1996-13	785	12	Hydro-jet House
	1996-14	786	12	Hydro-jet House
	1996-15	787	12	Hydro-jet House
	1996-16	788	12	Hydro-jet House
	4500-00	963	12	Dehy Press House
	4501-00	964	12	Alcohol Pump & Accumulator House
	4506-00	968	12	Ingredient Mix House
	4508-01	969	12	Mixer-Macerator House
	4508-02	970	12	Mixer-Macerator House
	4510-01	971	12	Block Press House
	4510-02	972	12	Block Press House
	4510-03	973	12	Block Press House
	4513-01	974	12	Final Press House
	4513-02	975	12	Final Press House
	4513-03	976	12	Final Press House
	4516-01	977	12	Cutting House
	4516-02	978	12	Cutting House
	4516-03	979	12	Cutting House

12/14/94	BUILDING NUMBER	REAL PROP NO.	AREA NO.	MODIFIED CARETAKER ACCOUNT DESCRIPTION
	4517-01	980	12	Loading Platform
	4517-02	981	12	Loading Platform
	4517-03	982	12	Loading Platform
	4521-00	983	12	Hydraulic Station
	4549-00	988	12	D-line Shop
	4554-00	989	12	D-line Office
	4555-00	990	12	ACR Building & Duct System
	4558-01	991	12	Material Storehouse
	4558-02	992	12	Material Storehouse
	4567-00	998	12	Material Store
	9062-19	409	12	Latrine, Men
	9062-20	410	12	Latrine, Men
	9062-23	413	12	Latrine, Men
	9062-26	416	12	Latrine, Men
	9062-29	419	12	Latrine, Men
	9063-06	430	12	Latrine, Women
	9063-07	431	12	Latrine, Women
	9063-08	432	12	Latrine, Women
	9063-13	437	12	Latrine, Women
Area 13	000E-03	1714	13	Steam Pressure Reducing Station
E-line SB	0923-04	460	13	Telpher system
	1600-28	510	13	Solvent Recovery House
	1600-29	511	13	Solvent Recovery House
	1600-30	512	13	Solvent Recovery House
	1650-27	551	13	Water Dry House
	1650-28	552	13	Water Dry House
	1650-29	553	13	Water Dry House
	1650-30	554	13	Water Dry House
	1725-11	589	13	Air Dry House
	1725-12	590	13	Air Dry House
	1750-19	614	13	Rest House
	1750-20	615	13	Rest House
	1750-21	616	13	Rest House
	1750-22	617	13	Rest House
	1750-23	618	13	Rest House
	1750-24	619	13	Rest House
	1852-03	647	13	Screen Storehouse
	1996-17	789	13	Hydro-jet House
	1996-18	790	13	Hydro-jet House
	5500-00	1031	13	Dehy Press House
	5501-00	1032	13	Alcohol Pump & Accumulator House
	5506-00	1036	13	Ingredient Mix House
	5508-01	1037	13	Mixer-Macerator House
	5508-02	1038	13	Mixer-Macerator House
	5510-01	1039	13	Block Press House
	5510-02	1040	13	Block Press House
	5510-03	1041	13	Block Press House
	5513-01	1042	13	Final Press House
	5513-02	1043	13	Final Press House

12/14/94	BUILDING NUMBER	REAL PROP NO.	AREA NO.	MODIFIED CARETAKER ACCOUNT DESCRIPTION
	5516-01	1044	13	Cutting House
	5516-02	1045	13	Cutting House
	5517-01	1046	13	Loading Platform
	5517-02	1047	13	Loading Platform
	5521-00	1048	13	Hydraulic Station
	5549-00	1049	13	E-line Shop
	5554-00	1050	13	E-line Office
	5555-00	1051	13	ACR Building & Duct System
	5558-01	1057	13	Material Storehouse
	5558-02	1058	13	Material Storehouse
	5567-00	1059	13	Material Store
	9062-21	411	13	Latrine, Men
	9062-24	414	13	Latrine, Men
	9062-27	417	13	Latrine, Men
	9062-31	421	13	Latrine, Men
	9063-09	433	13	Latrine, Women
	9063-10	434	13	Latrine, Women
	9063-14	438	13	Latrine, Women
	H7-L-06	1734	13	Steam Pressure Reducing Station
Area 14	8007-00	1563	14	Chemical Store
BP Aux.	8008-00	1564	14	NC Store
	8010-00	1566	14	Line Office
	8011-01	1567	14	Latrine
	8011-02	1568	14	Latrine
Area 15	000F-03	1717	15	Steam Pressure Reducing Station
BALL POWDER	0202-04	205	15	Parking Lot
	6543-05	1155	15	Gate House
	6543-14	1151	15	Inspection House
	9062-34	424	15	Latrine, Men
	9504-01	1638	15	Change House
	9504-02	1639	15	Change House
	9504-03	1640	15	Change House
	9504-04	1641	15	Change House
	9591-00	1667	15	Powder Grinding House
	9592-00	1668	15	Extraction House
	9593-00	1669	15	Solvent Storage House
	9594-00	1670	15	Solvent Receiving House
Area 16	6513-05	1070	16	Latrine
Rocket Paste	6513-29	1094	16	Latrine
	6701-00	1203	16	NC Blender House
	6709-14	1231	16	Pre Dry House
	6709-15	1232	16	Pre Dry House
	6709-16	1233	16	Pre Dry House
	6709-20	1237	16	Pre Dry House
	6709-22	1239	16	Pre Dry House
	6709-23	1240	16	Pre Dry House
	6709-24	1241	16	Pre Dry House

12/14/94	BUILDING NUMBER	REAL PROP NO.	AREA NO.	MODIFIED CARETAKER ACCOUNT DESCRIPTION
	6709-25	1242	16	Pre Dry House
	6709-26	1243	16	Pre Dry House
	6709-28	1245	16	Pre Dry House
	6726-02	1249	16	Paste Rest House
Area 17	0021-03	1761	17	Air Pressure Reducing Station
Rocket West	6513-25	1090	17	Latrine
	6513-26	1091	17	Latrine
	6513-45	1110	17	Latrine
	6531-01	1119	17	Transfer Shed
	6531-02	1120	17	Transfer Shed
	6550-00	1157	17	Maintenance Office
	6586-04	1164	17	Inert Storage
	6586-05	1165	17	Inert Storage
	6803-01	1259	17	Paste Rest House
	6803-02	1260	17	Paste Rest House
	6803-03	1261	17	Paste Rest House
	6803-04	1262	17	Paste Rest House
	6804-01	1267	17	Rest House
	6804-08	1274	17	Rest House
	6804-15	1281	17	Rest House
	6804-16	1282	17	Rest House
	6804-17	1283	17	Rest House
	6805-01	1288	17	Paste Weigh House
	6805-02	1289	17	Paste Weigh House
	6805-03	1290	17	Paste Weigh House
	6805-04	1291	17	Paste Weigh House
	6805-05	1292	17	Paste Weigh House
	6806-01	1298	17	Rework Roll House
	6806-02	1299	17	Rework Roll House
	6807-06	1307	17	Roll House
	6807-11	1312	17	Roll House
	6807-16	1317	17	Roll House
	6807-18	1319	17	Roll House
	6807-22	1323	17	Roll House
	6807-23	1324	17	Roll House
	6807-55	1351	17	Roll House
	6807-57	1353	17	Roll House
	6808-02	1359	17	Slitting & Carpet Roll House
	6808-03	1360	17	Slitting & Carpet Roll House
	6808-05	1362	17	Slitting & Carpet Roll House
	6808-07	1364	17	Slitting & Carpet Roll House
	6810-04	1385	17	Press House
	6810-07	1388	17	Press House
	6812-08	1433	17	Rest & Heating House
	6812-17	1442	17	Rest & Heating House
	6812-18	1443	17	Rest & Heating House
	6812-19	1444	17	Rest & Heating House
	6815-01	1458	17	Rest House
	6815-02	1459	17	Rest House

12/14/94	BUILDING NUMBER	REAL PROP NO.	AREA NO.	MODIFIED CARETAKER ACCOUNT DESCRIPTION
	6815-03	1460	17	Rest House
	6815-04	1461	17	Rest House
	6815-05	1462	17	Rest House
	6815-08	1465	17	Rest House
	6815-09	1466	17	Rest House
	6815-11	1468	17	Rest House
	6816-01	1471	17	Line Office
	6816-02	1472	17	Inspection House
	6816-03	1473	17	Inspection House
	6816-04	1474	17	Inspection House
	6816-05	1475	17	Inspection House
	6816-06	1476	17	Inspection House
	6816-09	1479	17	Inspection House
	6826-01	1492	17	Supersonic Scanning House
	6828-07	1500	17	Final Rest House
	6861-03	1514	17	Line Office
	6861-05	1516	17	Line Office
	6882-02	1541	17	Final Rest House
Area 18	0021-04	1762	18	Air Pressure Reducing Station
Rocket East	6513-27	1092	18	Latrine
	6513-28	1093	18	Latrine
	6513-31	1096	18	Latrine
	6513-32	1097	18	Latrine
	6513-33	1098	18	Latrine
	6513-34	1099	18	Latrine
	6513-35	1100	18	Latrine
	6513-36	1101	18	Latrine
	6513-37	1102	18	Latrine
	6513-38	1103	18	Latrine
	6513-39	1104	18	Latrine
	6513-40	1105	18	Latrine
	6513-41	1106	18	Latrine
	6513-42	1107	18	Latrine
	6513-47	1112	18	Latrine
	6513-48	1113	18	Latrine
	6513-49	1114	18	Latrine
	6513-50	1115	18	Latrine
	6530-02	1118	18	Line Office
	6803-05	1263	18	Paste Rest House
	6803-06	1264	18	Paste Rest House
	6803-07	1265	18	Paste Rest House
	6803-08	1266	18	Paste Rest House
	6804-14	1280	18	Rest House
	6804-18	1284	18	Rest House
	6804-19	1285	18	Rest House
	6804-20	1286	18	Rest House
	6804-21	1287	18	Rest House
	6805-08	1295	18	Paste Weigh House
	6805-09	1296	18	Paste Weigh House

12/14/94	BUILDING NUMBER	REAL PROP NO.	AREA NO.	MODIFIED CARETAKER ACCOUNT DESCRIPTION
	6805-10	1297	18	Paste Weigh House
	6806-03	1300	18	Rework Roll House
	6806-04	1301	18	Rework Roll House
	6807-28	1326	18	Roll House
	6807-29	1327	18	Roll House
	6807-30	1328	18	Roll House
	6807-31	1329	18	Roll House
	6807-32	1330	18	Roll House
	6807-33	1331	18	Roll House
	6807-36	1332	18	Roll House
	6807-37	1333	18	Roll House
	6807-38	1334	18	Roll House
	6807-39	1335	18	Roll House
	6807-40	1336	18	Roll House
	6807-41	1337	18	Roll House
	6807-42	1338	18	Roll House
	6807-43	1339	18	Roll House
	6807-44	1340	18	Roll House
	6807-45	1341	18	Roll House
	6807-46	1342	18	Roll House
	6807-47	1343	18	Roll House
	6807-48	1344	18	Roll House
	6807-49	1345	18	Roll House
	6807-50	1346	18	Roll House
	6807-51	1347	18	Roll House
	6807-52	1348	18	Roll House
	6807-53	1349	18	Roll House
	6807-58	1354	18	Roll House
	6807-59	1355	18	Roll House
	6807-60	1356	18	Roll House
	6807-61	1357	18	Roll House
	6808-09	1366	18	Slitting & Carpet Roll House
	6808-10	1367	18	Slitting & Carpet Roll House
	6808-11	1368	18	Slitting & Carpet Roll House
	6808-12	1369	18	Slitting & Carpet Roll House
	6808-13	1370	18	Slitting & Carpet Roll House
	6808-14	1371	18	Slitting & Carpet Roll House
	6808-15	1372	18	Slitting & Carpet Roll House
	6808-16	1373	18	Slitting & Carpet Roll House
	6810-17	1398	18	Press House
	6810-18	1399	18	Press House
	6810-19	1400	18	Press House
	6810-20	1401	18	Press House
	6810-21	1402	18	Press House
	6810-22	1403	18	Press House
	6810-23	1404	18	Press House
	6810-24	1405	18	Press House
	6810-25	1406	18	Press House
	6810-26	1407	18	Press House
	6810-27	1408	18	Press House

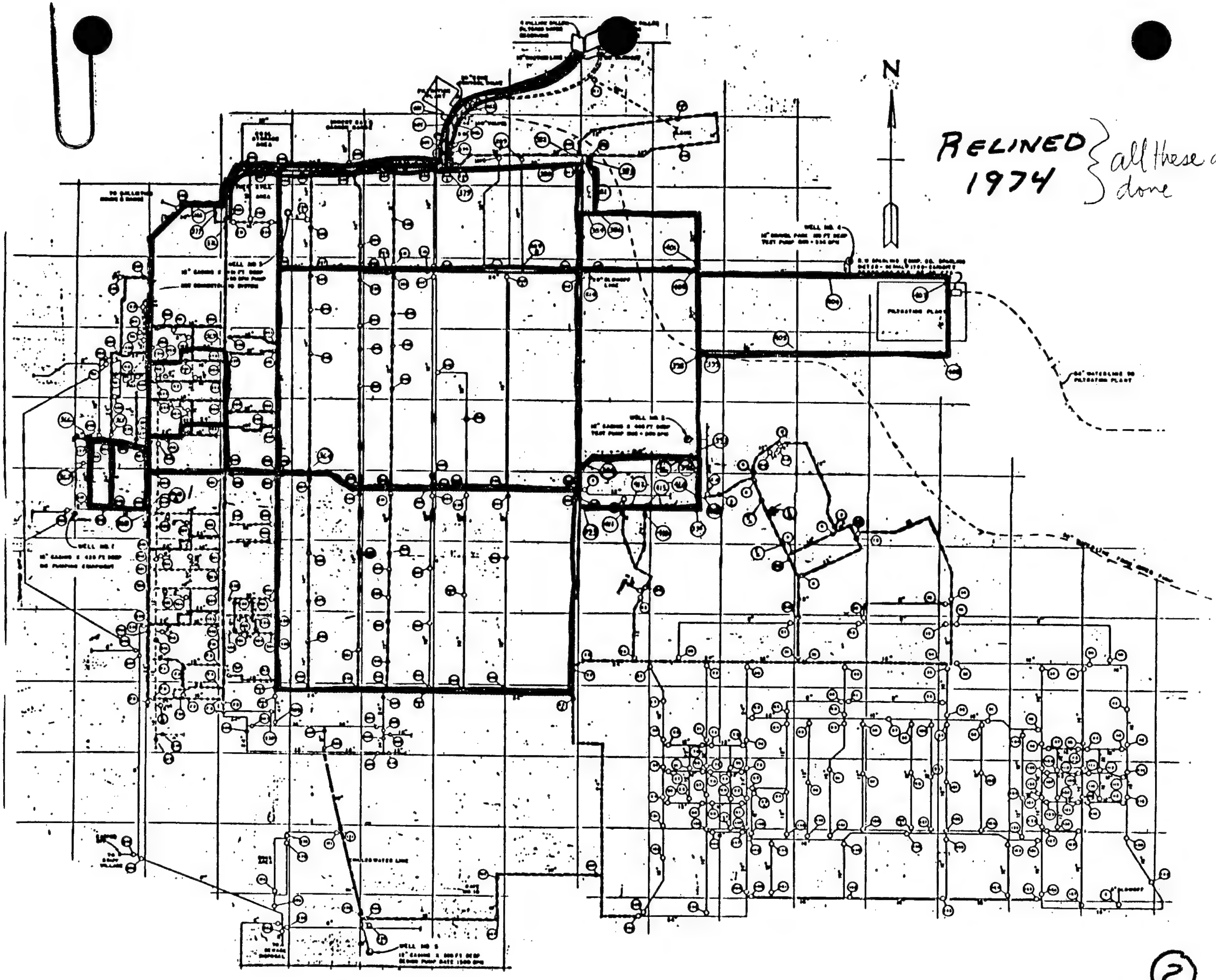
12/14/94	BUILDING NUMBER	REAL PROP NO.	AREA NO.	MODIFIED CARETAKER ACCOUNT DESCRIPTION
	6810-28	1409	18	Press House
	6810-29	1410	18	Press House
	6810-30	1411	18	Press House
	6810-31	1412	18	Press House
	6810-32	1413	18	Press House
	6810-39	1420	18	Press House
	6810-40	1421	18	Press House
	6810-41	1422	18	Press House
	6810-42	1423	18	Press House
	6810-43	1424	18	Press House
	6810-44	1425	18	Press House
	6812-11	1436	18	Rest & Heating House
	6812-12	1437	18	Rest & Heating House
	6812-13	1438	18	Rest & Heating House
	6812-14	1439	18	Rest & Heating House
	6812-15	1440	18	Rest & Heating House
	6812-16	1441	18	Rest & Heating House
	6812-20	1445	18	Rest & Heating House
	6812-21	1446	18	Rest & Heating House
	6812-22	1447	18	Rest & Heating House
	6814-06	1453	18	Milling House
	6814-07	1454	18	Milling House
	6814-08	1455	18	Milling House
	6814-09	1456	18	Milling House
	6814-10	1457	18	Milling House
	6815-06	1463	18	Rest House
	6815-07	1464	18	Rest House
	6815-10	1467	18	Rest House
	6815-12	1469	18	Rest House
	6815-13	1470	18	Rest House
	6816-07	1477	18	Inspection House
	6816-08	1478	18	Inspection House
	6816-10	1480	18	Inspection House
	6823-02	1491	18	Oil Storage
	6826-03	1494	18	Supersonic Scanning House
	6828-03	1498	18	Final Rest House
	6828-04	1499	18	Final Rest House
	6828-09	1502	18	Final Rest House
	6828-10	1503	18	Final Rest House
	6829-04	1507	18	Rest House
	6850-02	1511	18	Wax Purification & Die Warming House
	6861-04	1515	18	Line Office
	6864-02	1520	18	Cementing House
	6868-04	1524	18	Annealing House
	6868-05	1525	18	Annealing House
	6868-06	1526	18	Annealing House
	6868-09	1529	18	Annealing House
	6953-02	1545	18	Rework Rest House
	6955-02	1547	18	Rework Heating House
	6955-03	1548	18	Rework Heating House

12/14/94	BUILDING NUMBER	REAL PROP NO.	AREA NO.	MODIFIED CARETAKER ACCOUNT DESCRIPTION
	6956-02	1550	18	Rework Cutting House
	6956-03	1551	18	Rework Cutting House
	6957-02	1553	18	Rework Sorting & Weigh House
	6957-03	1554	18	Rework Sorting & Weigh House
	9061-05	389	18	Sewage Lift Station
	H46L-21	1756	18	Steam Pressure Reducing Station
Area 19	3566-02	926	19	Caustic Screen Cleaning House
Prod. Support	4502-00	965	19	Ether Still House
	5502-00	1033	19	Ether Still House
Area 20	1900-04	667	20	Magazine, Standard
Magazine/	1900-05	668	20	Magazine, Standard
Burning Ground	1900-06	669	20	Magazine, Standard
	1900-07	670	20	Magazine, Standard
	1900-08	671	20	Magazine, Standard
	1906-01	672	20	Magazine, Standard
	1906-02	673	20	Magazine, Standard
	1906-03	674	20	Magazine, Standard
	1906-04	675	20	Magazine, Standard
	1906-05	676	20	Magazine, Standard
	1906-06	677	20	Magazine, Standard
	1906-07	678	20	Magazine, Standard
	1906-08	679	20	Magazine, Standard
	1906-09	679A	20	Magazine, Standard
	1906-10	680	20	Magazine, Standard
	1906-11	681	20	Magazine, Standard
	1906-12	682	20	Magazine, Standard
	1906-13	683	20	Magazine, Standard
	1906-14	684	20	Magazine, Standard
	1906-15	685	20	Magazine, Standard
	1906-16	686	20	Magazine, Standard
	1906-17	687	20	Magazine, Standard
	1906-18	688	20	Magazine, Standard
	1906-19	689	20	Magazine, Standard
	1906-20	690	20	Magazine, Standard
	1906-21	691	20	Magazine, Standard
	1906-22	692	20	Magazine, Standard
	1906-23	693	20	Magazine, Standard
	1906-24	694	20	Magazine, Standard
	1906-25	695	20	Magazine, Standard
	1906-26	696	20	Magazine, Standard
	1906-27	697	20	Magazine, Standard
	1906-28	698	20	Magazine, Standard
	1906-29	699	20	Magazine, Standard
	1906-30	700	20	Magazine, Standard
	1906-31	701	20	Magazine, Standard
	1906-32	702	20	Magazine, Standard
	1906-33	703	20	Magazine, Standard
	1906-34	704	20	Magazine, Standard

12/14/94	BUILDING NUMBER	REAL PROP NO.	AREA NO.	MODIFIED CARETAKER ACCOUNT DESCRIPTION
	1906-35	705	20	Magazine, Standard
	1906-36	706	20	Magazine, Standard
	1906-37	707	20	Magazine, Standard
	1906-38	708	20	Magazine, Standard
	1906-39	709	20	Magazine, Standard
	1906-40	710	20	Magazine, Standard
	1906-41	711	20	Magazine, Standard
	1906-42	712	20	Magazine, Standard
	1906-43	713	20	Magazine, Standard
	1906-44	714	20	Magazine, Standard
	1906-45	715	20	Magazine, Standard
	1906-46	716	20	Magazine, Standard
	1906-47	717	20	Magazine, Standard
	1906-48	718	20	Magazine, Standard
	1906-49	719	20	Magazine, Standard
	1906-50	720	20	Magazine, Standard
	1906-51	721	20	Magazine, Standard
	1906-52	722	20	Magazine, Standard
	1906-53	723	20	Magazine, Standard
	1906-54	724	20	Magazine, Standard
	1906-55	725	20	Magazine, Standard
	1906-56	726	20	Magazine, Standard
	9101-00	1763	20	Segregated Ammunition Storehouse
	9102-02	1765	20	Magazine, Igloo
	9102-03	1766	20	Magazine, Igloo
Area 21	0308-01	258	21	Cannon Powder Magazine
Ballistics/	0308-02	259	21	Cannon Powder Magazine
Laboratories	0308-03	260	21	Cannon Powder Magazine
	0312-00	262	21	Wash Rack
	0316-00	266	21	Igniter Magazine
	0318-00	267	21	Waste Storage
	6878-00	1536	21	Black Powder Magazine
Area 22	0204-B1	214	22	Gate House
Administration/	0204-B2	1887	22	Gate House
Change Houses	0271-00	244	22	Patrol Equipment Storage
	2557-00	857	22	Change House, Gate 1
	5504-01	1034	22	Change House, Gate 1
	5504-02	1035	22	Change House, Gate 1
	5557-02	1053	22	Change House, Gate 1
	5557-03	1054	22	Change House, Gate 1
	6532-01	1122	22	Change House, Gate 16
	6532-02	1123	22	Change House, Gate 16
	6532-03	1124	22	Change House, Gate 16
	6532-04	1125	22	Change House, Gate 16
	6532-05	1126	22	Change House, Gate 16
	6532-06	1127	22	Change House, Gate 16
	6532-07	1128	22	Change House, Gate 16
	6532-16	1137	22	Change House, Gate 16

12/14/94	BUILDING NUMBER	REAL PROP NO.	AREA NO.	MODIFIED CARETAKER ACCOUNT DESCRIPTION
	6532-17	1138	22	Change House, Gate 16
	6532-18	1139	22	Change House, Gate 16
	6532-19	1140	22	Change House, Gate 16
	6532-20	1141	22	Change House, Gate 16
Area 23	0041-00	1760	23	Steam Pressure Reducing Station
Shops/Stores	0534-00	329	23	Fire Station #2
	0933-00	472	23	Fuel Oil Storage
	6513-11	1076	23	Latrine
	6543-02	1152	23	Gate House
	6543-04	1154	23	Gate House
	6543-11	1148	23	Inspection House
	6543-13	1150	23	Inspection House
Area 24	0402-00	270	24	Coal Yard
Utilities	0425-00	296	24	pH Recorder
	0429-01	1892	24	Storage Shed, General Purpose
	0429-02	1893	24	Storage Shed, General Purpose
	0944-00	1771	24	Settling Pond
	6538-00	1146	24	Powerhouse #2

RELINED 1974 } all these are done



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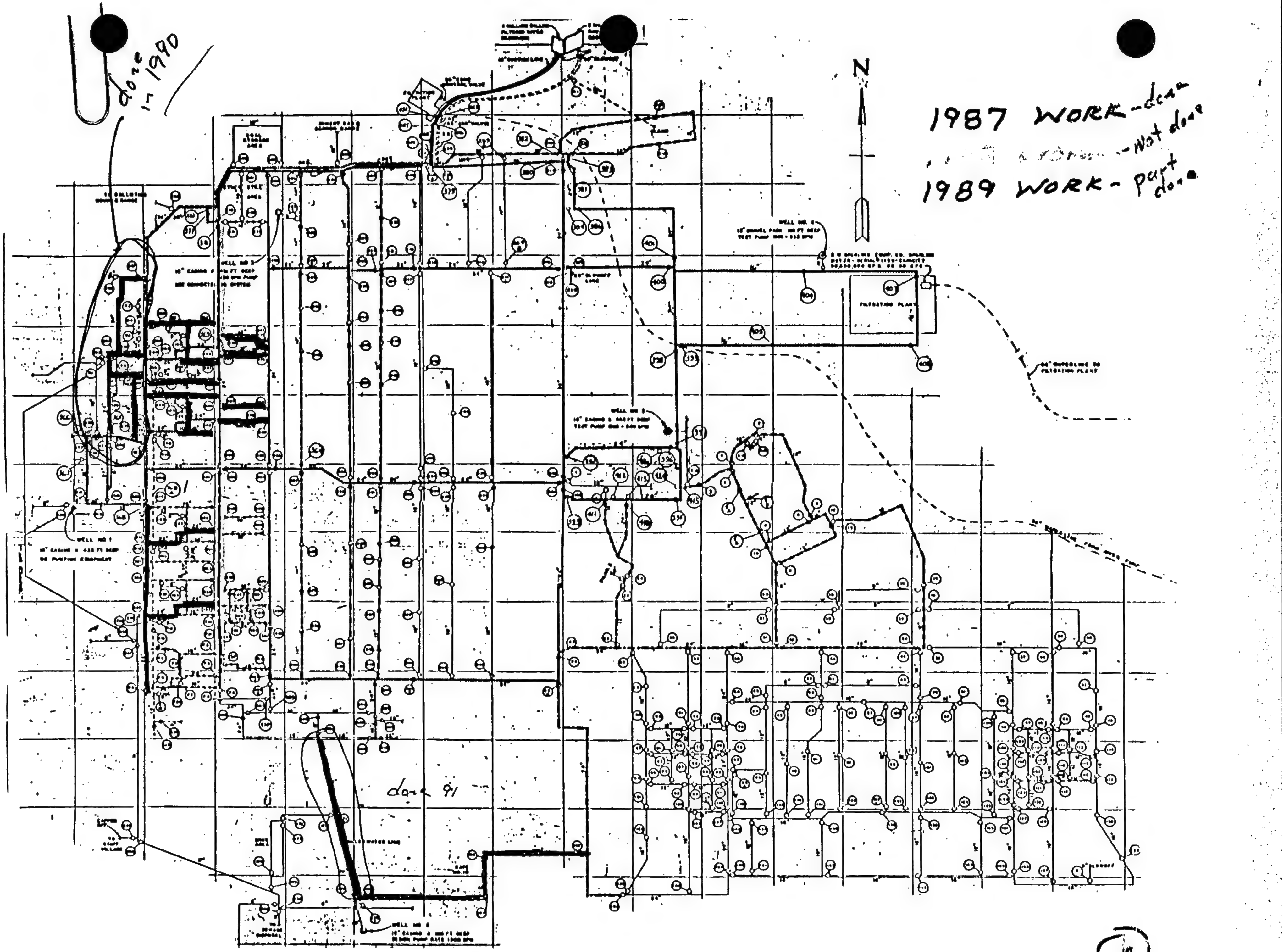
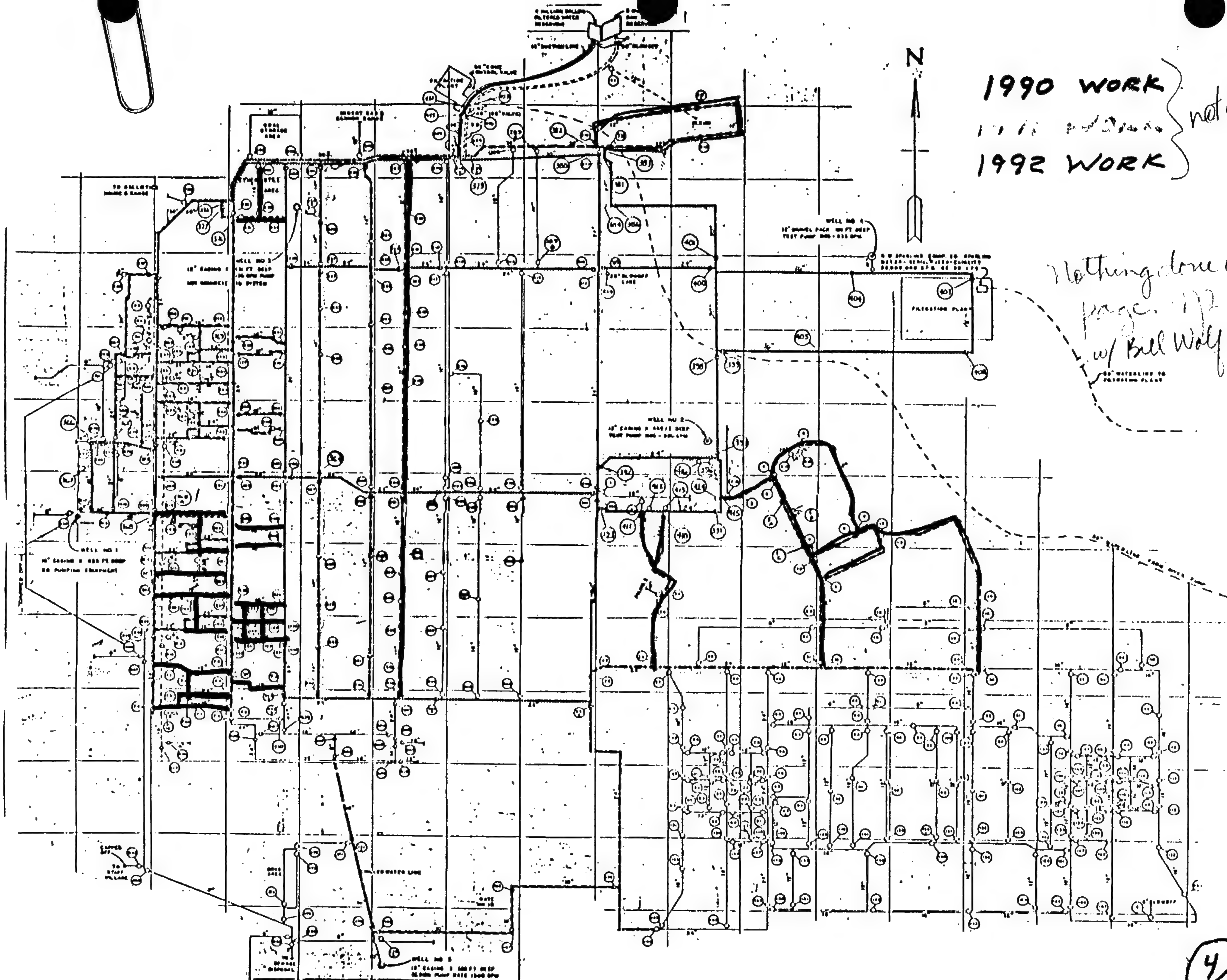


N
1987 WORK - done
- Not done
1989 WORK - part done
done in 1990
done 91
WELL NO. 1
WELL NO. 3
WELL NO. 4
WELL NO. 5
WELL NO. 6
FILTRATION PLANT



1990 WORK
1992 WORK
not done

Nothing done on this page. 12/?/2004 w/ Bill Wolf

4

APPENDIX C

LEAK DETECTION SURVEY

Leak Detection Summary
1994 Leak Detection Report
Previous Leak Detection Report Summary

E M C Engineers, Inc.
Badger Army Ammunition Plant
EMC #1406-004

Leak Detection Summary

Response to Comment #4 BAAP

Prepared by: T Poeling
7/26/95
Checked by: _______

BADGER ARMY AMMUNITIONS PLANT LEAK SUMMARY

TYPE OF LEAK	LOCATION/ DESCRIPTION	SIZE (GPD)	CARETAKER AREA NO.	FULL/PARTIAL CARETAKER	COMMENTS/ PIPE/VALVE SIZE
Fire Hydrant	Hydrant #2	750	-		
Valve - Packing	Valve #N20750	750	21	Partial	1-1/2" Valve
Fire Hydrant	Hydrant #3	750	-		
Fire Hydrant	Hydrant #4	750	-		
Fire Hydrant	Hydrant #11	750	1	Full	
Fire Hydrant	Hydrant #25	750	22	Partial	
Fire Hydrant	Hydrant #133	750	24	Partial	
Fire Hydrant	Hydrant #153	750	-		Quit leaking when tightened
Fire Hydrant	Hydrant #63	750	-		
Fire Hydrant	Hydrant #76	750	-		
Main Line	Near Bldg 4508-1 by Hydrant #177	3,000	12	Full	16" Line
Service Line	Bldg. 4506	3,000	12		Quit leaking when tightened
Valve	Valve #185	2,000	-		24" Valve
Valve	Valve #325 (323)	2,000	-		16" Valve
Fire Hydrant	Hydrant #91	750	-		
Valve - Packing	Valve #F10	750	8	Partial	24" Valve
Valve - Packing	Valve #338	750	8	Full	24" Valve
Valve	Valve #E2455	2,000	8	Full	24" Valve
Fire Hydrant	Hydrant #271	750	-		
Fire Hydrant	Hydrant #396	750	1	Full	
Main Line	Across from Bldg. #1600-33	35,000	-		14" Line
Fire Hydrant	Hydrant #298	750	-		
Fire Hydrant	Hydrant #374P	750	-		
Main Line	Next to Hyd. #239	35,000	-		14" Line
Fire Hydrant	Hydrant #241	750	-		
Fire Hydrant	Hydrant #242	750	-		
Fire Hydrant	Hydrant #278	750	-		
Fire Hydrant	Hydrant #279	750	-		
Fire Hydrant	Hydrant #379	750	-		
Fire Hydrant	Hydrant #356	750	11	Partial	
Fire Hydrant	Hydrant #406	750	-		
Fire Hydrant	Hydrant #450	750	3	Partial	
Fire Hydrant	Hydrant #254	750	12	Full	
Fire Hydrant	Hydrant #344	750	12	Full	
Main Line	Near Bldg. 1996-17	35,000	13	Partial	14" Line
Fire Hydrant	Hydrant #319	750	13	Full	
Fire Hydrant	Hydrant #347	750	12	Partial	
Fire Hydrant	Hydrant #473	750	16	Partial	
Fire Hydrant	Hydrant #475	750	16	Partial	
Main Line	Near Bldg. 1650-41	35,000	-		14" Line
Fire Hydrant	Hydrant #266	750	-		
Fire Hydrant	Hydrant #267	750	-		
Fire Hydrant	Hydrant #504	750	17		Quit leaking when tightened
Fire Hydrant	Hydrant #508	750	17	Partial	
Fire Hydrant	Hydrant #518	750	17	Partial	

E M C Engineers, Inc.
Badger Army Ammunition Plant
EMC #1406-004

Leak Detection Summary

Prepared by: T Poeling
7/26/95
Checked by: _______

TYPE OF LEAK	LOCATION/ DESCRIPTION	SIZE (GPD)	CARETAKER AREA NO.	FULL/PARTIAL CARETAKER	COMMENTS/ PIPE/VALVE SIZE
Fire Hydrant	Hydrant #464 (564)	750	17	Partial	
Fire Hydrant	Hydrant #548	750	17	Partial	
Fire Hydrant	Hydrant #549	750	17	Partial	
Fire Hydrant	Hydrant #555	750	17	Partial	
Fire Hydrant	Hydrant #556	750	17		Quit leaking when tightened
Fire Hydrant	Hydrant #567	750	17	Partial	
Fire Hydrant	Hydrant #573	750	17	Partial	
Fire Hydrant	Hydrant #577	750	17	Partial	
Fire Hydrant	Hydrant #584	750	18		Quit leaking when tightened
Fire Hydrant	Hydrant #640	750	18	Full	
Fire Hydrant	Hydrant #513	750	17	Partial	
Fire Hydrant	Hydrant #526	750	17	Partial	
Fire Hydrant	Hydrant #529	750	17	Partial	
Valve - Packing	Valve #162	2,000	17	Full	16" Valve
Fire Hydrant	Hydrant #551	750	17	Partial	
Fire Hydrant	Hydrant #571	750	17		Quit leaking when tightened
Fire Hydrant	Hydrant #592	750	18	Partial	
Fire Hydrant	Hydrant #421	750	-		
Valve - Packing	Valve #353	750	-		6" Valve

SUMMARY

Total Loss - Main Line	143,000
Total Loss - Valves	6,000
Total Loss - Packing Valves	5,000
Total Loss - Service Line	3,000
Total Loss - Fire Hydrants	37,500
Total Loss - All Leaks (GPD)	194,500

E M C ENGINEERS, INC.
2750 S. Wadsworth Blvd.
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(303) 988-2951
9755 Dogwood Rd.
Suite 220
Roswell, GA 30075
(404) 642-1864

JOB 1406.004 BAAP
SHEET NO. 1 OF 1
CALCULATED BY TCP DATE 4-25-95
CHECKED BY ______ DATE ______
SCALE ______

Percentage of Leakage at Full Production Rates

Assume BAAP has the same amount of usage for fire protection, irrigation, and evaporation.

Assume BAAP is using process water at the rate required for Base line Mobilization.

Assume leakage is increased by the amount given in the 1989 Wells Engineers report.

∴ Fire protection, irrigation, evaporation usage : 20,000,000 gal/yr.

Base Line Mobilization (from Wells report) : 50,850,000 gpd
= 18,560,000,000 gal/yr.

Potential Leakage (EMC) = 155,645,100 gal/yr
Leakage (Wells) = 419,750,000 gal/yr.

Total Leakage : 575,395,100 gal/yr.

Total Usage : 19,155,400,000 gal/yr.

% Leakage = 3.0 %

BADGER WATER USE

Base Line Mobilization

Production Area		Gals Per Day Water Use Treated	Raw
BALL POWDER		5,750,000	
Raw Water			1,000,000
Rocket		2,650,000	
Smokeless	- B-Line	450,000	
	- C-Line	450,000	
	- D-Line	450,000	
	- E-Line	100,000	
Nitrocellulose	- B-Line	5,400,000	
	- C-Line	5,400,000	
	- D-Line	5,400,000	
	- E-Line	5,400,000	
	- F-Line	1,900,000	
Raw Water			4,000,000
Ether/Alcohol		3,000,000	
Nitroglycerin	- Old	750,000	
	- New	100,000	
Acid Area	- Old	4,550,000	
	- New	2,000,000	
Raw Water			4,000,000
Powerhouse	- #1	3,000,000	
	- #2	1,400,000	
Filtration Plant		2,150,000	
Domestic			550,000
Leakage & Losses		1,150,000	
Subtotal		52,000,000	9,000,000
TOTAL	61,000,000 Gals/Day		
Full Mobilization		30,000,000	1,000,000
Subtotal		82,000,000	10,000,000
TOTAL	92,000,000 Gals/Day		

* Provided by Olin Corp.; April 28, 1989

Taken From Appendix B
1989 Wells Engineers Report

M.E. SIMPSON Co., Inc.

P.O. Box 1995
Valparaiso, IN 46384

800/255-1521
Fax: 219/531-2444

Branch office:
Grayslake, IL

November 11, 1994

Mr. Michael Scholz, P.E.
Project Manager
EMC Engineers, Inc.
2750 S. Wadsworth Blvd., Suite C-200
Denver, CO 80227

Dear Scholz,

M.E. Simpson Company is a professional & technical service company that offers Leak Survey Programs, Large Meter Testing and Repair Programs, Water Main Location, and Valve Exercising, Location and Computer Mapping Programs. These **"Professional Services"** offered by M. E. Simpson Company are designed to aid a utility in reducing unaccounted for water and recovering lost revenue.

M. E. Simpson Company is pleased to submit this report of our leak detection survey for the Badger Army Ammunition Plant. This survey addressed the B.A.A.P. water distribution system, consisting of approximately 117 miles of water main. The report contains the results of our investigation that includes the following:

1. A LISTING OF THE MEETINGS HELD WITH B.A.A.P. PERSONNEL
2. A DESCRIPTION OF THE AREA SURVEYED.
3. METHODOLOGY OF THE SURVEY
4. A LIST OF LEAKS AND TYPE OF LEAK LOCATED.
5. GENERAL RECOMMENDATIONS BASED ON OUR INVESTIGATION.

LISTING OF THE MEETINGS HELD WITH B.A.A.P. PERSONNEL

M.E. Simpson Company personnel held numerous meetings with B.A.A.P. personnel to keep them updated on the progress of the leak survey. The following is a listing of the meetings, who was there and what discussed:

10/17/94 - Project briefing - Michael Scholz, EMC
Dennis Jones, EMC
Greg Engel, M.E. Simpson Company
Chris Brown, M.E. Simpson Company
Michael Simpson, M.E. Simpson Company
Donald Hartman, B.A.A.P./Government
Randy Sprecher, Olin Corp.
Bill Wolf, Olin Corp.

10/17/94 - facility tour, conducted by Randy Sprecher - M. Simpson, G. Engel, C. Brown, M. Scholz and D. Jones

10/18/94 - project briefing of the area we were working in - Gordy Muehe, G. Engel, C. Brown

10/19/94 - project briefing of the area we were working in - Gordy Muehe, G. Engel, C. Brown

10/21/94 - project briefing of the Rocket area we were working in - Gordy Muehe, G. Engel, C. Brown

10/21/94 - project briefing of the area we were working in - Donald Hartman, G. Engel, C. Brown

10/24/94 - project briefing of the area we were working in - Gordy Muehe, G. Engel, C. Brown

10/25/94 - project briefing of the area we were working in - Gordy Muehe, G. Engel, C. Brown

10/26/94 - project briefing of the area we were working in - Gordy Muehe, G. Engel, C. Brown

10/27/94 - project briefing, gave complete update and overview of everything that was surveyed and leaks found - Bill Wolf, Randy Sprecher, Don Hartman, G. Engel and C. Brown

10/31/94 - project briefing, discussed re-pressurizing the 24" watermain so it could be surveyed - Gordy Muehe, G. Engel and C. Brown

11/01/94 - project briefing of the area we were working in - Gordy Muehe, G. Engel, C. Brown

11/02/94 - project briefing, gave complete update and overview of everything that was surveyed and leaks found. Also discussed, was the cooperation of the "pipe shop". The cooperation has been excellent - Bill Wolf, Randy Sprecher, Donald Hartman, G. Engel and C. Brown

11/03/94 - project briefing, discussed the excavation of several leaks that had been located. The "pipe shop" immediately responded and excavated each leak - Gordy Muehe, G. Engel and C. Brown

11/03/94 - project briefing, gave final list of all leaks and reviewed the survey - Gordy Muehe, G. Engel and C. Brown

11/03/94 - project briefing, reviewed the survey and answered questions - Randy Sprecher, G. Engel and C. Brown

DESCRIPTION OF THE AREA SURVEYED

Approximately 617,760 lineal feet was surveyed as part of the system investigation. This included all fire hydrants, all accessible mainline valves, and 200 services.

METHODOLOGY

M.E. Simpson Company used the **FLUID CONSERVATION SYSTEMS S20** listening device along with the **MP90** preamplifier-transducer system to conduct your survey. Our experienced technicians used these devices as listening equipment to survey the pipeline network. <u>Each hydrant, and accessible valves</u> were used as listening points to identify leaks. Service, b-boxes, (200) were used to keep the listening distances under three fifty hundred feet (350'). **"Pin-Pointing"** of the leak, as well as locating leaks that other methods failed to reveal was done with the **90/90** and or **C2000 LEAK CORRELATORS,** the latest state of the art leak computers. These electronic instruments are microprocessor units that measure the time it takes the sound of the leak to travel from the leak to the point where the leak correlator is connected to the water line. By connecting the leak correlator to the water line at two locations, it will compute the distance from the leak to each connection point thus enabling us to determine the exact leak location. The results of the leak survey, including an estimate of water loss for the leaks identified, is documented in this report.

LEAKAGE LOCATED

All water mains within the project area were surveyed and sixty four leaks were located. There were five main line leaks, one service line leak, eight valve leaks, and the balance fire hydrant leaks. All of these leaks have been verbally reported to your office with their location, so many have probably been repaired already. Following are the leak locations with an estimated GPD (Gallons Per Day) leakage potential:

TYPE	LOCATION	SIZE
Sec. - P1		
Fire Hydrant	Hyd. #2 next to Bld. #6873 see enclosed diagram	750 GPD
Sec. - P2		
Valve (packing)	Valve #N20750 next to Bld. #6878 see enclosed diagram	750 GPD
Fire Hydrant	Hyd. #3 see enclosed diagram	750 GPD
Fire Hydrant	Hyd. #4 see enclosed diagram	750 GPD
Sec. - P3		
Fire Hydrant	Hyd. #11 next to Bld. #720-1 see enclosed diagram	750 GPD
Sec. - P4		
Fire Hydrant	Hyd. #25 see enclosed diagram	750 GPD
Sec. - P7		
Fire Hydrant	Hyd. #133 see enclosed diagram	750 GPD
Sec. - P9		
Fire Hydrant	Hyd. #153 next to Bld. #2549 see enclosed diagram	750 GPD
Sec. - P10		
Fire Hydrant	Hyd. #63 next to Bld. #3003-4-6 see enclosed diagram	750 GPD
Fire Hydrant	Hyd. #76 across from Bld. #3020 see enclosed diagram	750 GPD

TYPE	LOCATION	SIZE
Sec. - P11		
Main Line	Near Bld. #4508-1 next to Hyd. #177 see enclosed diagram	3,000 GPD
Service Line	Bld. #4506 see enclosed diagram	3,000 GPD
Valve	Valve #185 see enclosed diagram	2,000 GPD
Valve	Valve #323 see enclosed diagram	2,000 GPD
Fire Hydrant	Hyd. #91 next to Bld. #4030 see enclosed diagram	750 GPD
Sec. - P12		
Valve (packing)	Valve #F10 see enclosed diagram	750 GPD
Valve (packing)	Valve #338 see enclosed diagram	750 GPD
Valve	Valve #E2455 next to Bld. #5037 see enclosed diagram	2,000 GPD
Sec. - P14		
Fire Hydrant	Hyd. #271 see enclosed diagram	750 GPD
Sec. - P19		
Fire Hydrant	Hyd. #396 see enclosed diagram	750 GPD
Sec. - P20		
Main Line	Across from Bld. #1600-33 next to tracks see enclosed diagram	35,000 GPD
Fire Hydrant	Hyd. #298 see enclosed diagram	750 GPD
Sec. - P21		
Fire Hydrant	Hyd. #374P next to Bld. #8014 see enclosed diagram	750 GPD

TYPE	LOCATION	SIZE
Sec. - P25		
Main Line	Next to Hyd. #239 south of valve #E42+25 see enclosed diagram	35,000 GPD
Fire Hydrant	Hyd. #241 see enclosed diagram	750 GPD
Fire Hydrant	Hyd. #242 see enclosed diagram	750 GPD
Fire Hydrant	Hyd. #278 see enclosed diagram	750 GPD
Fire Hydrant	Hyd. #279 see enclosed diagram	750 GPD
Sec. - P26		
Fire Hydrant	Hyd. #379 see enclosed diagram	750 GPD
Sec. - P32		
Fire Hydrant	Hyd. #356 see enclosed diagram	750 GPD
Sec. P33		
Fire Hydrant	Hyd. #406 next to Bld. #1875-2 see enclosed diagram	750 GPD
Sec. P34		
Fire Hydrant	Hyd. #450 see enclosed diagram	750 GPD
Sec. P35		
Fire Hydrant	Hyd. #254 see enclosed diagram	750 GPD
Sec. P36		
Fire Hydrant	Hyd. #344 next to Bld. #906-2-29 see enclosed diagram	750 GPD

TYPE	LOCATION	SIZE
Sec. - P41		
Main Line	Near Bld. #1996-17 next to tracks see enclosed diagram	35,000 GPD
Fire Hydrant	Hyd. #319 see enclosed diagram	750 GPD
Sec. - P42		
Fire Hydrant	Hyd. #374 see enclosed diagram	750 GPD
Sec. - P44		
Fire Hydrant	Hyd. #473 see enclosed diagram	750 GPD
Sec. - P45		
Fire Hydrant	Hyd. #475 see enclosed diagram	750 GPD
Sec. - P48		
Main Line	Near Bld. #1650-41 north of Hyd. #296 see enclosed diagram	35,000 GPD
Fire Hydrant	Hyd. #266 see enclosed diagram	750 GPD
Fire Hydrant	Hyd. #267 see enclosed diagram	750 GPD
Sec. - P53		
Fire Hydrant	Hyd. #504 see enclosed diagram	750 GPD
Fire Hydrant	Hyd. #508 see enclosed diagram	750 GPD
Fire Hydrant	Hyd. #518 see enclosed diagram	750 GPD
Sec. - P54		
Fire Hydrant	Hyd. #564 see enclosed diagram	750 GPD
Fire Hydrant	Hyd. #548 see enclosed diagram	750 GPD

TYPE	LOCATION	SIZE
Sec. - P54 (cont.)		
Fire Hydrant	Hyd. #549 see enclosed diagram	750 GPD
Fire Hydrant	Hyd. #555 see enclosed diagram	750 GPD
Fire Hydrant	Hyd. #556 see enclosed diagram	750 GPD
Fire Hydrant	Hyd. #567 see enclosed diagram	750 GPD
Fire Hydrant	Hyd. #573 see enclosed diagram	750 GPD
Fire Hydrant	Hyd. #577 see enclosed diagram	750 GPD
Fire Hydrant	Hyd. #584 see enclosed diagram	750 GPD
Sec. - P55		
Fire Hydrant	Hyd. #640 see enclosed diagram	750 GPD
Sec. - P56		
Fire Hydrant	Hyd. #513 see enclosed diagram	750 GPD
Fire Hydrant	Hyd. #526 see enclosed diagram	750 GPD
Fire Hydrant	Hyd. #529 see enclosed diagram	750 GPD
Sec. - P57		
Valve (packing)	Valve #162 see enclosed diagram	750 GPD
Fire Hydrant	Hyd. #551 see enclosed diagram	750 GPD
Fire Hydrant	Hyd. #571 see enclosed diagram	750 GPD
Fire Hydrant	Hyd. #592 see enclosed diagram	750 GPD

TYPE	LOCATION	SIZE
Sec. - P60		
Fire Hydrant	Hyd. #421 see enclosed diagram	750 GPD
Sec. - P61		
Fire Hydrant	Hyd. #353 see enclosed diagram	750 GPD
ESTIMATED LEAKAGE TOTAL		**194,500 GPD**

LEAK QUANTITIES

Quantifying leaks is difficult because there is not any accurate means of doing so. Pipe material, size of the leak, system pressure, soil material and water table will effect the noise that a leak makes. Small leaks under high system pressure will make more noise than a large leak under low system pressure. However, the above leaks are of sufficient noise levels that the above estimates should be very conservative. Using a production price of $.25 per thousand gallons, these leaks were costing your utility in excess of $48.00 per day or $17,520.00 annually. It obvious that this Leak Survey Program has proven to be very cost effective. Naturally the main line leaks have the greatest potential for loss followed by service line, valves, and finally hydrants. Once leaks have been repaired, we would recommend that the Utility compare pumping rates before and after. This information will be more meaningful and accurate.

RECOMMENDATIONS

This survey confirms that the B.A.A.P. water distribution system will benefit from this project by a reduction in underground leakage. There is always a concern over the cost effectiveness of leak detection because of the uncertainty of the number of leaks located. However, with your present cost of water and the discovery of these sixty four leaks, the cost of this 1994 leak survey will pay for itself within 12 months. It only takes a recovery of about 190,000 gallons per day on an annual basis (190,000 gallons per day is only 131.9 gallons per minute throughout your entire water distribution system) to recover your investment. We would recommend that you conduct a Leak Survey Program every year. This recommendation becomes more critical as your cost of water increases. We would also like to recommend that the policy towards fire hydrant operation be changed. M.E. Simpson Company would also recommend that the policy regarding the closure of fire hydrants be changed. After contacting six major hydrant manufacturers, <u>B.A.A.P. should close their hydrants until **tight**</u>. This will help in reduce water loss.

We appreciate the cooperation of Mr. Sprecher, Mr. Wolf, Mr. Muehe, and his staff who were available to answer our questions during this project. If you have any questions with the information in this report, please do not hesitate to call.

Sincerely Yours,

Gregory J. Engel
Project Manager

Michael D. Simpson
Operations Manager

Encl.: Photos of the project

REPORT
ON
PITOMETER WATER WASTE SURVEY
BADGER ARMY AMMUNITION PLANT
OLIN CORPORATION
DEFENSE SYSTEMS GROUP
BARABOO, WISCONSIN
1990

The Pitometer Associates
Engineers
Montclair, N.J.

(16)

LEAKAGE SUMMARY

The following is a summary of the leakage located during the survey. Leaks are divided into type and total amount of leakage for each type.

Number Of Leaks	Type	Estimated Leakage-gpd.
Phase I - Suspect Areas - Open		
1	Main leak	2,000
7	Hydrant leaks	26,000
1	Service lateral leak	10,000
9	Total Leakage - Phase I	38,000
Phase II - Remainder of Open Mains		
1	Main leak	10,000
21	Hydrant leaks	94,000
1	Service lateral leak	2,000
23	Total Leakage - Phase II	106,000
Phase III - Closed Mains		
1	Main leak	10,000
12	Hydrant leaks	48,000
13	Total Leakage - Phase III	58,000
45	Total Leakage	202,000

APPENDIX D

ENERGY AUDIT CALCULATIONS

Energy Cost Calculations
Leakage Density Calculations
ECO #1 LCCA
ECO #2 LCCA
ECO #3 LCCA
ECO #4 LCCA
Cost Estimate Cut Sheets

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Cost of Water Lost - Leakage

- The process water system will soon get water from two sources: ① Pump + Treat (IRM) Facility
  ② Ground water from Wells #4 + #5
- The pump + treat facility will have the capability of producing 500 gpm to the process water system using a 40 hp motor.
- Assume that the IRM facility pump is running 24 hrs/day in order to produce 21,960,000 gallons per month.
- According to water logs over the past 3 years, water demand has exceeded 21,960,000 per month for about four months out of the year (on average).
- Calculations show that approximately 12,000,000 gallons will have to be produced by the wells to supplement the IRM facility. (Wells will run 4 months out of the year)
- Total water use for process water system is based on historical meter data.
- Total process water use (avg. over last 3 years) = 250,900,000 gal/year.
- Process water from wells ≈ 12,000,000 gal/year
- Process water from IRM facility = 238,900,000 gal/year.
- Assume that Well #4 (100 hp) will supply the majority of well water. According to nameplate data, Well #4 supplies a flowrate of 935 gpm.

$$\text{Annual operating hours (Well \#4)} = \frac{12{,}000{,}000 \text{ gal}}{935 \text{ gal/min}} = 12{,}835 \text{ min}$$

Annual operating hours = 215 hours

Assume conservative estimate = 250 hours (14,000,000 gal/yr.)

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Cost of Water Lost - Leakage

IRM Facility: Assume 236,900,000 gal/yr. (250,900,000 - 14,000,000)

$$\text{Annual operating hours} = \frac{236{,}900{,}000 \text{ gal}}{500 \text{ gal/min}} = 473{,}800 \text{ min.}$$

$$\boxed{\text{Annual operating hours} = 7{,}900}$$

Electrical Costs

Assume: $\boxed{KW = \frac{(HP)(0.746\ ^{KW}/_{HP})(LF)}{\eta_m}}$ $\boxed{KWH = KW(\text{Hours})}$

where KW = demand
HP = nameplate horsepower
LF = load factor on motor (assume 75% average)
η_m = motor efficiency (assume for standard efficiency motor)

IRM Facility: $KW = \frac{(40\text{ hp})(0.746\ ^{KW}/_{HP})(0.75)}{0.895} = \boxed{25.0 \text{ KW}}$

$KWH = (25.0\text{ KW})(7900 \text{ hours}) = \boxed{197{,}500 \text{ KWH}}$

$$\text{Cost} = \frac{(12)(KW)(\$/KW) + (KWH)(\$/KWH)}{\text{Annual water produced (1000 gal)}}$$

$$\text{Cost} = \frac{(12)(25.0\text{ KW})(\$6.82/KW) + (197{,}500 \text{ KWH})(\$0.0374/KWH)}{236{,}900{,}000 \text{ gal/yr.}}$$

$$\text{Cost} = \frac{\$9433}{236{,}900 \text{ (1000 gal)}} = \boxed{\$0.0398 / 1000 \text{ gal}}$$

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JOB 1406.004 BAAP

CALCULATED BY TCP DATE 4-15-95

CHECKED BY DATE

SCALE

Cost of Water Lost - Leakage

Well #4 $KW = \frac{(100 hp)(0.746 \text{ KW/HP})(0.75)}{0.915} = \boxed{61.1 \text{ KW}}$

$KWH = (61.1 \text{ KW})(250 \text{ hours}) = \boxed{15,275 \text{ KWH}}$

$$Cost = \frac{(4 \text{ mos.})(61.1 \text{ KW})(\$6.82/\text{KW}) + (15,275 \text{ KWH})(\$0.0374/\text{KWH})}{14,000,000 \text{ gal/yr.}}$$

$$Cost = \frac{\$2,238}{14,000 (1000 \text{ gal})} = \boxed{\$0.160/1000 \text{ gal}}$$

Total cost of water is proportioned among the two water sources according to water capacity pumped.

$$\text{Total Cost} = \frac{[(\text{Cost})(\text{Water Produced})]_{\text{IRM}} + [(\text{Cost})(\text{Water Produced})]_{\text{well}}}{\text{Total Water Produced}}$$

$$\text{Total Cost} = \frac{[(\$0.0398)(236,900,000 \text{ gal}) + (\$0.16)(14,000,000 \text{ gal})]}{250,900,000 \text{ gal}}$$

$$\boxed{\text{Total Cost} = \$0.047/1000 \text{ gal}}$$

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CALCULATED BY TCP DATE 4-17-95
CHECKED BY ______ DATE ______
SCALE ______

Leakage Savings - Various Water Pumping Costs

Proportion of budget for process water system = 90%

Well Maintenance

Annual budget for all wells = \$75,000

Well Maint. Cost = $\frac{\text{Annual budget}}{\text{Annual water production}} = \frac{(\$75{,}000)(0.90)}{250{,}900{,}000 \text{ gals}}$

$\boxed{\text{Well Maintenance Cost} = \$0.27/1000 \text{ gal}}$

Distribution Maintenance

Based on last 3 years data, average maintenance costs for all wells = \$339,845.

Distribution Maint. Cost = $\frac{(\$339{,}845)(0.90)}{250{,}900{,}000 \text{ gal}}$

$\boxed{\text{Dist. Maintenance Cost} = \$1.22/1000 \text{ gal}}$

Chemical Treatment

\$9,000 annual cost for chemical treatment (chlorine)

Treatment Costs = $\frac{(\$9{,}000)(0.90)}{250{,}900{,}000 \text{ gal}}$

$\boxed{\text{Treatment Costs} = \$0.032/1000 \text{ gal}}$

Table 2. Nominal Full-Load Efficiencies from the National Energy Policy Act of 1992

Motor (hp)	Number of Poles					
	Open Motors			Closed Motors		
	2	4	6	2	4	6
1	—	82.5	80.0	75.5	82.5	80.0
1.5	82.5	84.0	84.0	82.5	84.0	85.5
2	84.0	84.0	85.5	84.0	84.0	86.5
3	84.0	86.5	86.5	85.5	87.5	87.5
5	85.5	87.5	87.5	87.5	87.5	87.5
7.5	87.5	88.5	88.5	88.5	89.5	89.5
10	88.5	89.5	90.2	89.5	89.5	89.5
15	89.5	91.0	90.2	90.2	91.0	90.2
20	90.2	91.0	91.0	90.2	91.0	90.2
25	91.0	91.7	91.7	91.0	92.4	91.7
30	91.0	92.4	92.4	91.0	92.4	91.7
40	91.7	93.0	93.0	91.7	93.0	93.0
50	92.4	93.0	93.0	92.4	93.0	93.0
60	93.0	93.6	93.6	93.0	93.6	93.6
75	93.0	94.1	93.6	93.0	94.1	93.6
100	93.0	94.1	94.1	93.6	94.5	94.1
125	93.6	94.5	94.1	94.5	94.5	94.1
150	93.6	95.0	94.5	94.5	95.0	95.0
200	94.5	95.0	94.5	95.0	95.0	95.0

Notes: 1) Manufactured by October 25, 1997
2) Manufactured by October 25 1999 for motors requiring certification from a nationally recognized safety testing laboratory.

ıotors where efficiency, full load speed, power factor, cost and other ıformation are available. Because no one manufacturer has the most ficient motor in every size or type, users should comparison shop. lanufacturers also change their designs from time to time, so it is very nportant to obtain up-to-date efficiency, full load speed, cost, etc., inforıation from the manufacturers.

Table 3. Typical Efficiencies of Electric Motors

Typical Standard Motors			Typical Energy-Efficient Motors		
Full Load Efficiencies of NEMA Design B Induction Motors			Full Load Efficiencies of Three Phase, Four Pole Motors		
hp	Nominal Efficiency Range	Average Nominal Efficiency	hp	Nominal Efficiency Range	Average Nominal Efficiency
1.0	68.0-78.0	73.0	1.0	80.0-84.0	83.0
1.5	68.0-80.0	75.0	1.5	81.0-84.0	83.0
2.0	72.0-81.0	77.0	2.0	81.0-84.0	83.0
3.0	74.0-83.0	80.0	3.0	83.5-89.5	86.5
5.0	78.0-85.0	82.0	5.0	85.0-90.2	87.6
7.5	80.0-87.0	84.0	7.5	86.0-91.0	88.5
10.0	81.0-88.0	85.0	10.0	87.5-91.7	89.6
15.0	83.0-89.0	86.0	15.0	89.5-92.4	91.0
20.0	84.0-89.0	87.5	20.0	90.0-93.2	91.6
25.0	85.0-90.0	88.0	25.0	91.0-94.1	92.6
30.0	86.0-90.5	88.5	30.0	91.0-94.5	92.8
40.0	87.0-91.5	89.5	40.0	91.5-94.5	93.0
50.0	88.0-92.0	90.0	50.0	91.5-95.0	93.2
60.0	88.5-92.0	90.5	60.0	91.7-95.0	93.3
75.0	89.5-92.5	91.0	75.0	92.0-95.0	93.5
100.0	90.0-93.0	91.5	100.0	93.0-95.0	94.0
125.0	90.5-93.0	92.0	125.0	93.0-95.4	94.2
150.0	91.0-93.5	92.5	150.0	93.5-95.8	94.6
200.0	91.5-94.0	93.0	200.0	94.4-96.2	95.3

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ECIP Projects - Assumptions

ECO#1 - Fix leakage identified by leak detection survey

- Perform water audit: A water audit of BAAP's process water system shall be performed according to AWWA Manual 36 "Water Audits and Leak Detection." The total water produced from the IRM Facility and the wells is assumed to be the average volume of water pumped into the process water system for the last 3 years. (250,900,000 gal/yr).

All water uses at BAAP are largely unmetered. It is assumed that there are 5 major uses:

1. Exercising of fire hydrants (fire protection)
2. Irrigation
3. Some industrial uses
4. Reservoir evaporation
5. Leakage

All other minor uses, such as meter error, drain flushing, landscaping, reservoir seepage, accounting errors will be assumed to be minimal.

- According to AWWA Manual 36, assume that only operation and maintenance costs that vary with the amount of water pumped will be included in water costs. In this case, maintenance costs were assumed to be budgeted and fixed.
- According to AWWA Manual 36, assume that 75% of all potential losses (leakage) can be recovered.

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ECIP Projects - Assumptions

ECO#1 - Fix leakage identified by leak detection surveys

- Assume that the leakage rate of the distribution system is essentially constant. Data from the past 10 years reveals that water usage from the wells has remained relatively constant. This is due to the efforts of the maintenance personnel, who repair leakage on a steady basis.

- The cost of leak repair is not included in this ECO. Since leaks are continually discovered and repaired in the normal course of utility operations, the leaks found in the leak detection program would be repaired eventually. If the leaks are repaired as a part of the leak detection program, as is BAAP's policy, BAAP avoids the expense of repairing them as they are discovered accidentally. Although the savings of future repair costs can be significant, they are often overlooked when estimating the savings of leak detection programs. The actual costs of repairing leaks in a program vs. the costs of repairing the leaks under normal maintenance programs is classified as being very small. (AWWA Manual 36, pg. 32, 1990). Therefore, to simplify the calculations, the cost of repairs is assumed to be zero.

- Assume that other maintenance costs (well, distribution, maintenance ~~chemical treatment~~) will not change as a result of a leak detection program. When leaks are fixed, new leaks will emerge. (Assumption 1) Assume that, because the leakage rates will remain constant, the need for maintenance will not be affected.

- However, there will be an energy (pumping) savings assumed because of ECO #1 implementation. By taking leakage uses out of the system, pumping energy will be saved. If leaks aren't fixed, more and more pumping energy will be expended to pump more water. There is also a chemical treatment savings for water saved.

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JOB 1406.004 BAAP
SHEET NO. ~~6~~ 7 OF 8
CALCULATED BY TCP DATE 4-17-95
CHECKED BY ____ DATE ____
SCALE ____

ECIP Projects - Assumptions

ECO#2 - Relining leaky pipe (Designated by BAAP maintenance)

- Relining leaky pipe will accomplish two desired tasks.
- It will serve to stop any current leaks, which will save energy costs. Also, it will save future maintenance costs because this pipe won't leak for the immediate future. This savings will also be transferred down to well maintenance and chemical treatment costs.
- We will assume that relined piping will remain relatively leak free for the period of energy study, 20 years.
- The value of all potential leakage saved along the full length of the rehabilitated pipe must be accounted for. Therefore, a leakage density factor (number of leaks / foot of pipe / inch diameter of pipe) will be applied to the pipe to be rehabilitated. This value will produce an assumed amount of leakage saved in the relined pipe over the life of the study.

ECO#3 - Isolating specific "Caretaker" areas

Isolating "Caretaker" areas will effectively reduce the amount of distribution piping in the network. Not only will current leaks in those areas be eliminated, all future leaks in those areas will also be taken care of.

In addition, all future maintenance requirements in those areas will be eliminated; saving well, distribution, and chemical treatment costs.

In order to quantify these potential leaks, a leakage density was calculated (gpm leakage per foot of pipe per inch diameter). This potential leakage savings will be shown separately from actual current leakage savings.

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JOB 1406.004 BAAP
SHEET NO. 8 OF 8
CALCULATED BY TCP DATE 4-22-95
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Comparing Pumping Costs - Process Water System

Criteria: 250,900,000 gal/yr. must be pumped
\$0.0374/KWH, \$6.82/KW

Well: 100 hp motor, Capacity = 935 gpm, η_m = 91.5%

Req'd operating hours = $\frac{250{,}900{,}000 \text{ gal}}{935 \text{ gpm}}$ = $\underline{4{,}475 \text{ hrs}}$

$KW = \frac{(100 \text{ hp})(0.746 \text{ KW/HP})(0.75)}{0.915} = \underline{61.1 \text{ KW}}$

$KWH = (61.1 \text{ KW})(4{,}475 \text{ hrs}) = \underline{273{,}425 \text{ KWH}}$

$Cost = \frac{(12)(61.1 \text{ KW})(\$6.82/\text{KW}) + (273{,}425 \text{ KWH})(\$0.0374/\text{KWH})}{250{,}900{,}000 \text{ gals}}$

$\boxed{Cost = \$0.061/1000 \text{ gals}}$

IRM Facility: 40 hp motor, 500 gpm capacity, η_m = 89.5%

Req'd operating hours = $\frac{250{,}900{,}000 \text{ gal}}{500 \text{ gpm}}$ = $\underline{8{,}365 \text{ hrs.}}$

$KW = \frac{(40 \text{ hp})(0.746 \text{ KW/HP})(0.75)}{0.895} = \underline{25.0 \text{ KW}}$

$KWH = (25.0 \text{ KW})(8{,}365 \text{ hrs}) = \underline{209{,}125 \text{ KWH}}$

$Cost = \frac{(12)(25.0 \text{ KW})(\$6.82/\text{KW}) + (209{,}125 \text{ KWH})(\$0.0374/\text{KWH})}{250{,}900{,}000 \text{ gals}}$

$\boxed{Cost = \$0.039/1000 \text{ gal}}$

$\therefore$ $\boxed{\text{Pumping Savings} = \$5{,}520/\text{yr.}}$

Wisconsin Power & Light Company

WP&L

ACCOUNT NUMBER	450032-010	NEXT METER READING	10/28,10/29	PREVIOUS BALANCE	$ 0.00

Questions? Problems? Concerns?
Please call the appropriate number below:

Customer Service/Billing 1-800-937-0189
Electric Emergency/Outage 1-800-862-6261
Gas or Water Emergency 1-800-862-6263

CURRENT BALANCE	$ 8,703.67
AMOUNT DUE	$ 8,703.67
DATE DUE	OCT 18, 1994

OLIN CORP BAAP
US HIGHWAY 12
BARABOO WI 53913

0930000000678-5

Invoice Number: 450032U093094

Location Number

INDUSTRIAL
Electric Time of Day Meter: 061684523
Billed for 30 Days

ENERGY CHARGES
Meter Reading
Sep 29 9716
Aug 30 - 9660 = 56 X 4000.000 Multiplier = 224000 KWH
103,268 On Peak KWH X $ 0.025060 = $ 2,587.90
120,732 Off Peak KWH X $ 0.016740 = $ 2,021.05
Total Energy Charge .... = $ 4,608.95

REACTIVE ENERGY CHARGES
Meter Reading
Sep 29 2174
Aug 30 - 2174 = 0 X 4000.000 Multiplier = 0 RKVAH
Billed Reactive Energy = 0 - (224,000 X .484) = -108,416
-108,416 X $ 0.000946 .... = $ 102.56CR

DEMAND CHARGES
504 On Peak KW Recorded at 01:00 P.M. on 08/30/94
488 Off Peak KW Recorded at 07:45 A.M. on 08/31/94
504 KW X $ 6.820000 .... = $ 3,437.28

CUSTOMER DEMAND CHARGES
800 Off Peak KW Recorded at 11:00 P.M. on 01/18/94
800 KW X $ 0.300000 .... = $ 240.00

CUSTOMER CHARGE .... = $ 500.00

8,683.67

Certified for Payment
in Accordance with
Contract DAAA09-62-C-0302

Wisconsin sales tax exempt or not applicable.

MISCELLANEOUS CHARGE

Billing from Aug 30 to Sep 29
DEMAND PLOT .... $ 20.00
$ 20.00

Jack H. Coyle Jr.
Certifying Officer

Wisconsin sales tax exempt or not applicable.

TOTAL .... $ 8,703.67

Your Utility payment of $ 9,820.66 was received on 09/23/94.

Thank you.

COMPARISON	This Month	This Month Last Year
Ave. Temp.	65	60
Degree Days	83	211

COMPARISON	This Month	This Month Last Year
Elec days	30	30
Elec KWH	224,000	228,000
Elec $/day	$ 289.46	Unavailable
Power Factor	100	Unavailable
Load Factor	.620	Unavailable

Wisconsin Power & Light Company

WP&L

ACCOUNT NUMBER	450032-010	Please Return This Stub With Your Payment.	PREVIOUS BALANCE	$ 0.00

CURRENT BALANCE	$ 8,703.67
AMOUNT DUE	$ 8,703.67
DATE DUE	OCT 18, 1994

3

S ICBG-BAR

OLIN CORP BAAP
ATTN:JACK H COYLE JR
SMCBA-CA
BADGER ARMY AMMUNI-
TION PLANT
BARABOO WI 53913

WISCONSIN POWER & LIGHT
P.O. BOX 2960
MADISON, WI 53701-2960

AMOUNT ENCLOSED	

Please Do Not Write In White Area Below.

450032010300000870367941018941112 28

Water Treatment Costs (chlorine) ≈ $4,000 annually

- Basis of 25¢/1000 gals.

25,000,000 gals usage per month
(1 person) & $75,000 annual operating budget for Wells
(maintenance, operating supplies, electricity, overhead, samples, operation, etc.)
Note: Cost of water does not include any expenses on distribution system.

25¢/1000 gal used for economic analysis for water conservation projects.

- Areas in Modified Caretaker

Old Acid
Old Steam
East Rocket — Not West Rocket
"E" & "F" NC LINES
"D" & "E" SINGLE BASE
nitro cellulose

[illegible]

13 - Water Mains W.O. [illegible] C/c 9770

Maintenance Hours - [illegible] hrs.

Maintenance Labor - $[illegible]

Maintenance Overhead - $83,110.65

$[illegible]7,434.54

Total Dollars = $358,727.00

1992 - Water Mains W.O. 85410 C/c 9740

Maintenance Hours - 8,139.4 hrs

Maintenance Labor - $185,877.03

Maintenance Overhead - $99,549.45

$285,426.48

Total Dollars - $[illegible]

1994 - Water Mains W.O. 88190 - Thru September 9/12

Maintenance Hrs. - 1925.7

Maintenance Labor - $45,186.42

Maintenance Overhead $30,552.35

$75,738.77

2567. hrs

$60,250

40,800

101,050

Total Dollars $137,028

Average extrapolated through years end → $182,658

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Leakage Density Factor (Flow per length of pipe per diameter)

Assumption: Unaccounted for and future leakage make up a substantial portion of the total amount of process water used. It was assumed that the amount of leakage remains fairly constant. This assumption was made because water usage over the last 10 years has remained fairly constant.

In order to quantify future leakage, a leakage density factor will be calculated for the process water system. It is important to develop predictive water usage (leakage) models that realistically reproduce the water system's condition. This model was based on the following assumptions:

- The process water system is comprised primarily of larger steel mains and cast iron piping. It is assumed that the percentage of steel pipe vs. the percentage of cast iron pipe installed throughout BAAP is consistent.
- The process water system was installed at about the same time. Therefore, the majority of pipe is the same age.
- All pipe at BAAP is subjected to essentially the same soil conditions (external corrosion is the same throughout)
- Water quality in the pipes (internal corrosion) is the same.
- The environmental external loads on the system is essentially the same throughout. (Truck, train loads, frost, soil support, etc) Therefore, the industrial uses for the land above the process water system is similar.
- Costs associated with service disruption is small, and consistent throughout.

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Leakage Density Factor (cont)

- From all these conditions, the assumption is made that the process water system will experience a constant leakage throughout. Also, the leakage rate will vary based on the size of the pipe (larger pipes will leak more water than smaller pipes).
- To calculate the total process water system leakage density factor:

$$\boxed{\text{Density} = \frac{\text{Total Water Usage - Leakage (GPD)}}{[\Sigma(\text{Pipe Diameters} * \text{Pipe Length})]} = \text{Leakage (GPD)} / \text{Length (L.F.)} / \text{Diameter (in.)}}$$

- The assumption will be made in ECO #2 + #3 (Relining pipe with cement and Isolating "Caretaker" areas) that each ECO is a technique that will serve to eliminate current leakage in the system and any future leaks (at least for the life of the study).
- The amount of future potential leakage saved as a result of ECO #2 - #3 will be calculated by:

$$\text{Leakage Saved (GPD)} = [\text{Density Factor (Gpd/L.F./in)}] * [\text{Length of pipe (L.F.)}] * [\text{Diameter of Pipe (in.)}]$$

- Length of piping in the process water system was taken from 1989 (Wells Engineers) Water System Analysis. Table 6 (pg. 19).

LEAKAGE DENSITY CALCULATION

PIPE SIZE (in.)	PIPE LENGTH* (ft.)	PIPE LENGTH (mi.)	LENGTH*PIPE SIZE (ft-in)	LENGTH*PIPE SIZE (mi-in)
1	22,350	4.23	22,350	4.23
1 1/4	2,850	0.54	3,563	0.67
1 1/2	24,800	4.70	37,200	7.05
2	28,400	5.38	56,800	10.76
2 1/2	5,300	1.00	13,250	2.51
3	10,600	2.01	31,800	6.02
4	8,300	1.57	33,200	6.29
6	116,000	21.97	696,000	131.82
8	56,800	10.76	454,400	86.06
10	60,400	11.44	604,000	114.39
12	75,800	14.36	909,600	172.27
14	19,100	3.62	267,400	50.64
16	78,800	14.92	1,260,800	238.79
20	500	0.09	10,000	1.89
24	81,700	15.47	1,960,800	371.36
30	13,000	2.46	390,000	73.86
36	10,800	2.05	388,800	73.64
48	100	0.02	4,800	0.91
TOTAL(>4")	521,300	98.7	6,979,800	1,321.9
TOTAL	615,600	116.6	7,144,763	1,353.2

***Note: Pipe length taken from Table 6 (pg. 19) of 1989 Water System Analysis (Wells Engineers, Inc.)**

LEAKAGE	Scenario	Total Water Pumped	Potential Leakage	Recoverable Leakage	Detection Survey
	GPD	687,400	426,425	319,820	194,500
	GPM	477.4	296.1	222.1	135.1
DENSITY	GPD / LF - INCH DIAMETER	0.098	0.061	0.046	0.028
	GPD / MILES - INCH DIAMETER	507.99	315.13	236.35	143.74

CALCULATING POTENTIAL LEAKAGE

ECO DESCRIPTION	PIPE SIZE (IN.)	LEAKAGE (GPD/LF)	PIPE LENGTH (LF)	LEAKAGE (GPD)	LEAKAGE (kgal/yr)
ECO #2 - Relining leaky pipe	24	1.10	4,890	5,378	1,963
	14	0.64	6,720	4,311	1,573
Total - ECO #2			11,610	9,688	3,536
ECO #3A - Isolate Area #8	24	1.10	1,400	1,540	562
	16	0.73	2,150	1,576	575
	12	0.55	875	481	176
	10	0.46	210	96	35
	8	0.37	1,100	403	147
	6	0.27	2,350	646	236
	4	0.18	250	46	17
Total - ECO #3A			8,335	4,788	1,748
ECO #3B - Isolate Area #1	24	1.10	1,450	1,595	582
	12	0.55	160	88	32
	6	0.27	700	192	70
	3	0.14	450	62	23
	2	0.09	600	55	20
Total - ECO #3B			3,360	1,992	727
ECO #3C - Isolate Area #12	16	0.73	700	513	187
	12	0.55	975	536	196
	10	0.46	700	321	117
	8	0.37	1,450	532	194
	6	0.27	2,075	570	208
	1	0.05	2,050	94	34
Total - ECO #3C			7,950	2,566	937
ECO #3D - Isolate Area #13	24	1.10	690	759	277
	16	0.73	710	521	190
	12	0.55	1,400	770	281
	10	0.46	750	344	125
	8	0.37	700	257	94
	6	0.27	1,925	529	193
	4	0.18	175	32	12
	1	0.05	1,850	85	31
Total - ECO #3D			8,200	3,295	1,203
ECO #3E - Isolate Area #9	24	1.10	1,055	1,160	423
	16	0.73	1,750	1,283	468
	12	0.55	100	55	20
	10	0.46	1,680	770	281
	8	0.37	540	198	72
	6	0.27	1,430	393	143
	2	0.09	1,430	131	48
Total - ECO #3E			7,985	3,990	1,456
ECO #3F - Isolate Area #18	16	0.73	15,550	11,400	4,161
	12	0.55	11,225	6,172	2,253
	10	0.46	700	321	117
	8	0.37	5,050	1,851	676
	6	0.27	4,325	1,189	434
	2	0.09	8,250	756	276
Total - ECO #3F			45,100	21,689	7,917
Total - ECO #3			80,930	38,321	13,987

Piping Isolated - ECO#3 (Backup Quantity Takeoffs)

AREA #1 - OLD ACID

24": 730' + 310' + 50' + 340' = 1430'
12": 80' + 80' + = 160'
6": 90' + 55' + 220' + 75' + 110' + 75' + 80' = 705'
3": 200' = 200'
2½": 100' + 100' + 40' + 15' + = 255'
2": 60' = 60'
1½": 80' + 50' + 200' + 50' + 160' = 540'

AREA #8 - E-LINE NC

24": 550' + 125' + 180' + 55' + 115' + 240' + 85' + + 30' + 25' + = 1405'
16": 990' + 500' + 650' + = 2140'
12": 405' + 85' + 125' + 250' = 865'
8": 105' + 230' + 80' + 120' + 50' + 180' + 60' + 85' + 240' = 1090'
10": 100' + 110' = 210'
6": 120' + 160' + 195' + 175' + 150' + 60' + 85' + 85' + 45' + + 340' + 30' + 70' + 50' + 60' + 225' + 20' + 210' + 40 + 25' + 50' + 50' + 100' = 2350'
4": 130' + 90' = 220'

AREA #9 - E-LINE NC

24": 260' + 130' + 215' + 62' + 60' + 80' + 225' = 1055'
16": 460' + 470' + 215' + 110' + 485' = 1740'
12": 95' + = 100'
10": 215' + 185' + 200' + 55' + 50' + 135' + 75' + 200' + 160' + 40' + 365' + = 1680'
8": 520' + 20' + = 540'
6": 270' + 205' + 110' + 75' + 30' + 120' + 20' + 575' + 25' + = 1430'
2": 130' + 30' + 170' + 50' + 60' + 60' + 100' + 100' + 50' + 220' + 60' + 60' + 100' + 40' + 50' + 150' = 1430'

Piping Isolated - ECO #3 (Backup Quantity Takeoffs)

AREA #12 - D-LINE SB

16": 700' + = 700'
12": 575' + 205' + 185' = 965'
10": 700' = 700'
8": 80' + 135' + 130' + 725' + 175' + 100' + 100' = 1450'
6": 85' + 25' + 650' + 90' + 100' + 20' + 80'
+ 90' + 40' + 225' + 70' + 45' + 125' + 150'
+ 50' + 150' + 80' = 2075'
1": 460' + 100' + 200' + 420' + 50' + 300' + 200'
+ 300' = 2030'

AREA #13 - E-LINE SB

24": 690' = 690'
16": 710' + = 710'
12": 480' + 450' + 200' + 260' = 1390'
10": 730' + = 730'
8": 80' + 130' + 65' + 140' + 190' + 60' + 40' = 705'
6": 125' + 200' + 70' + 100' + 120' + 140' + 60' + 350' = 1925'
+ 60' + 60' + 45' + 130' + 275' + 60 + 100' + 30'
4": 75' + 100' = 175'
1": 480' + 460' + 200' + 400' + 60' + 100' + 40' = 1860'
+ 120'

AREA 18 - ROCKET EAST

16": 1245' + 946' + 437' + 175' + 270' + 1445' + 2310' + = 15550'
+ 945' + 1610' + 440' + 1610' + 1640 + 130' + 650 + 960' + 730'
12": 645' + 1160' + 550' + 470' + 840' + 550' + 1070' + 950' = 11,225'
+ 1160' + 1200' + 680' + 680' + 280' + 150' + 840
8": 200' + 700' + 1800' + 120' + 450' + 360' + 540' + 90' + 100' + 280' = 5050'
+ 225 + 180'
10": 600' + 100' = 700

Piping Deleted - ECO #3 (Backup Quantity Takeoffs)

AREA 18 - ROCKET EAST (cont)

6": 110' + 15' + 100' + 180' + 165' + 40' + 90' + 100' + 60' + 400' + 60' + 720' + 480 + 80' + 120' + 90' + 25' + 300' + 90' + 250' + 140' + 15' + 50' + 100' + 140' + 100 + 300' = 4320'

2": 500' + 475' + 420' + 600' + 990' + 240' + 200' + 140' + 460' + 120' + 435' + 120' + 70' + 720' + 450' + 1700' + 150' + 40' + 340' + 80' = 8250

LIFE CYCLE COST ANALYSIS SUMMARY
ENERGY CONSERVATION INVESTMENT PROGRAM (ECIP)

LOCATION: Badger Army Ammunition Plant REGION: 2 (Wisconsin) PROJECT NO: 1406-004
PROJECT TITLE: Leak Detection Study FISCAL YEAR: 1995
ANALYSIS DATE: 05/09/95 ECONOMIC LIFE: 20 PREPARED BY: T. Poeling

1. INVESTMENT: **ECO #1 - Implement Leak Detection Program**

A.	CONSTRUCTION COST	=	$18,000	
B.	SIOH COST	(6.0% of 1A) =	$1,080	
C.	DESIGN COST	(6.0% of 1A) =	$1,080	
D.	TOTAL COST	(1A +1B +1C) =	$20,160	
E.	SALVAGE VALUE OF EXISTING EQUIPMENT =		$0	
F.	PUBLIC UTILITY COMPANY REBATE =			
G.	TOTAL INVESTMENT	(1D -1E -1F) =	------->	$20,160

2. ENERGY SAVINGS (+) OR COST (-):
DATE OF NISTR 85-3273-9 USED FOR DISCOUNT FACTORS: JAN '95

	ENERGY SOURCE	FUEL COST $/KGAL (1)	SAVINGS KGAL/YR (2)	ANNUAL $ SAVINGS (3)	DISCOUNT FACTOR (4)	DISCOUNTED SAVINGS (5)	
A.	ELECT. (CURRENT)	$0.05	116,734	$5,486	15.88	$87,125	
B.	ELECT. (POTENTIAL)	$0.05	0	$0	15.88	$0	
C.	DIST	$5.00	0	$0	19.16	$0	
D.	NAT GAS	$4.00	0	$0	18.30	$0	
E.	COAL	$2.60	0	$0	16.62	$0	
G.	DEMAND SAV'GS (KW	$6.82	0	$0	14.88	$0	
H.	TOTAL		116,734	$5,486		-------->	$87,125

3. NON-ENERGY SAVINGS (+) OR COST (-)
A. ANNUAL RECURRING (+/-)

1 WELL MAINTENANCE ($0.27/KGAL)	$31,518	14.88	$468,990
2 WATER DIST. MAINTENANCE ($1.22/KGAL)	$0	14.88	$0
3 CHEMICAL TREAT. SAVINGS ($0.032/KGAL)	$3,735	14.88	$55,584
4 TOTAL ANNUAL DISC. SAVINGS (+) / COST (	$35,254		$524,574

B. NON-RECURRING (+/-)

ITEM	SAVINGS (+) COST(-) (1)	YEAR OF CCURRENCE (2)	DISCOUNT FACTOR (3) (TABLE A-2)	DISCOUNTED SAVINGS/ COST (4)
a.				$0
b.				$0
c.				$0
d. TOTAL	$0			$0

C. TOTAL NON-ENERGY DISCOUNTED SAVINGS (+) OR COST (-) (3A4 + 3Bd4) = $524,574

4.	FIRST YEAR DOLLAR SAVINGS (+) / COSTS (-)	(2H3+3A+(3Bd1/Economic Life))	$40,740
5.	SIMPLE PAYBACK (SPB) IN YEARS (MUST BE < 10 YEARS TO QUALIFY)	(1G/4) =	0.49
6.	TOTAL NET DISCOUNTED SAVINGS	(2H5 + 3C) =	$611,699
7.	DISCOUNTED SAVINGS-TO-INVESTMENT RATIO (SIR) (MUST HAVE SIR > 1.25 TO QUALIFY)	(6/1G) =	30.34

WATER AUDIT WORKSHEET

			Gallons/Year
Total Amount of Water Pumped (metered):			250,900,000
Unmetered Water Uses (Provided by BAAP):			
Fire hydrant exercising:	2000 gpm x 10 min x 675 hydrants	=	13,500,000
Industrial uses:			
Boilers	32,000,000 lbs/yr x 1,198 gals/lb	=	3,900,000
Cooling Water	40 gpm x 1,440 min/day x 365 days/yr	=	21,100,000
Domestic Water	525,000 gals/month x 12 months/yr	=	6,300,000
Maintenance Activities	20 gpm x 60 min/hr x 10 hrs/day x 4 days/wk x 52 wk/yr	=	2,500,000
Irrigation (Cattle)	400,000 gals/month x 6 months	=	2,400,000
Discovered Leaks (by maintenance personnel, not leak detection survey):			
Main water breaks	50 breaks x 20 gpm x 1,440 min/day x 30 days	=	43,200,000
Service laterals & valves	13 breaks x 2 gpm x 1,440 min/day x 30 days	=	1,123,200
Reservoir Evaporation (calculated value)		=	1,231,700
Total Identified Water Losses:			**95,254,900**
Potential Water System Leakage:			**155,645,100**
Recoverable Leakage (AWWA Manual 36 estimates 75% is recoverable):			**116,733,825**
Cost of Water Supply (per 1000 gallons):	$0.06 pumping costs, $0.032 chemical treatment $0.27 well maintenance		**$0.349**
One Year Benefit from Recoverable Leakage:			**$40,740**
Total Cost of Leak Detection Program:	$150 / mile x 120 miles	=	**$20,160**
Benefit to Cost Ratio:			**2.02**
Simple Payback (years):			**0.5**

 (Taken from AWWA Manual M36)

WATER AUDIT WORKSHEET

For: Badger Army Ammunition Plant Audit Study Period: Avg. Year (1992-1994)

Line	Item	Water Volume Subtotal	Total Cumulative	Units*
Task 1—Measure Supply				
1	Uncorrected total water supply to the distribution system (total of master meters)		250,900,000	gal/yr.
2A-C	Adjustments to total water supply			
2A	Source meter error (+ or –)	–		
2B	Change in reservoir and tank storage (+ or –)	–		
2C	Other contributions or losses (+ or –)	–		
3	Total adjustments to total water supply (add lines 2A, 2B, and 2C)	–		
4	Adjusted total water supply to the distribution system (add line 1 and line 3)		250,900,000	gal/yr.
Task 2—Measure Metered Use				
5	Uncorrected total metered water use	–		
6	Adjustments due to meter reading lag time (+ or –)	–		
7	Metered deliveries (add lines 5 and 6)	–		
8A-C	Total sales meter error and system-service meter errors (+ or –)			
8A	Residential meter error	–		
8B	Large meter error	–		
8C	Total (add line 8A and 8B)	–		
9	Corrected total metered water deliveries (add lines 7 and 8C)	–		
10	Corrected total unmetered water (subtract line 9 from line 4)		250,900,000	gal/yr.
11A-M	Authorized unmetered water uses			
11A	Firefighting and firefighting training	13,500,000		gal/yr.
11B	Main flushing	–		

NOTE: 1 ac-ft = 43,560 ft^3 = 325,851 gal.

*Units of measure must be consistent throughout the worksheet. The particular unit used (that is, acre-feet, millions of gallons, cubic feet, cubic metres, or other unit) is left to the user.

Form continues on next page.

Line	Item	Water Volume Subtotal	Total Cumulative	Units*
11A-M	Authorized unmetered water uses (continued)			
11C	Storm drain flushing	–		
11D	Sewer cleaning	–		
11E	Street cleaning	–		
11F	Schools	–		
11G	Landscaping in large public areas:			
	Parks	–		
	Golf courses	–		
	Cemeteries	–		
	Playgrounds	–		
	Highway median strips	–		
	Other landscaping	–		
11H	Decorative water facilities	–		
11I	Swimming pools	–		
11J	Construction sites	–		
11K	Water quality and other testing (pressure testing pipe, water quality, etc.)	–		
11L	Process water ~~at treatment plants~~ industrial uses	33,800,000		gal/yr.
11M	Other unmetered uses (irrigation)	2,406,000		gal/yr.
12	Total authorized unmetered water (add lines 11A through 11M)		49,700,000	gal/yr.
13	Total water losses (subtract line 12 from line 10)		201,200,068	gal/yr.
14A-H	Identified water losses			
14A	Accounting procedure errors	–		
14B	Illegal connections	–		
14C	Malfunctioning distribution system controls	–		
14D	Reservoir seepage and leakage	–		
14E	Evaporation	1,231,700		gal/yr.

NOTE: 1 ac-ft = 43,560 ft^3 = 325,851 gal.

*Units of measure must be consistent throughout the worksheet. The particular unit used (that is, acre-feet, millions of gallons, cubic feet, cubic metres, or other unit) is left to the user.

Form continues on next page.

Line	Item	Water Volume Subtotal	Total Cumulative	Units*
14A-H	Identified water losses (continued)			
14F	Reservoir overflow	–		
14G	Discovered leaks	44,323,200		gal/yr.
14H	Theft			
15	Total identified water losses (add lines 14A through 14H)	45,554,400		gal/yr.
16	Potential water system leakage (subtract line 15 from line 13)		155,645,100	gal/yr.
17	Recoverable leakage (multiply line 16 by 0.75)		116,733,825	gal/yr.

Line	Item	Dollars per Unit of Volume
18A-B	Cost savings	
18A	Cost of water supply	$0.047/1000 gal (Pumping Cost)
18B	Variable operation and maintenance costs	$0.302/1000 gal (Chemical Well Cost)
19	Total costs per unit of recoverable leakage (add line 18A and line 18B)	$0.349/1000 gal

Line	Item	Dollars per Year
20	One-year benefit from recoverable leakage (multiply line 17 by line 19)	$40,740
21	Total benefits from recovered leakage (multiply line 20 by 2)	$81,480
22	Total costs of leak detection project	$20,160
23	Benefit to cost ratio (divide line 21 by line 22)	4.04

Prepared by:

Name Tom Poeling

Title EMC Engineers, Inc. Date 4/20/95

NOTE: 1 ac-ft = 43,560 ft^3 = 325,851 gal.

*Units of measure must be consistent throughout the worksheet. The particular unit used (that is, acre-feet, millions of gallons, cubic feet, cubic metres, or other unit) is left to the user.

FACSIMILE TRANSMITTAL

Olin ORDNANCE

BADGER ARMY AMMUNITION PLANT

BARABOO, WISCONSIN
FAX: (608) 643-2674
TEL: (608) 643-3361

TO: Tom Poeling DATE: 20 April 1995

COMPANY: EMC Engineers

FACSIMILE PHONE NO: (303) 985-2527

FROM: Randy Sprecher

SUBJECT: Water Usage Data

ADDITIONAL INFORMATION: Attached is estimated annual water usage and water main repairs - as per your request.

Map showing mains to be given highest priority for relining will be mailed.

Concur with Confirmation Notices 2 & 3. No additional comments.

Thanks,

Randy Sprecher

Randy Sprecher

WE ARE TRANSMITTING 1 PAGES IN ADDITION TO THIS COVER SHEET

Water Usage Data

1) Agricultural Usage - Grazing & Irrigation

Use 400,000 gals/mo x 6 mos = 2,400,000 gals/yr.

2) Hydrant Flushing

675 hydrants x 2,000 gpm x 10 min. = 13,500,000 gals/yr.

3) Process Water

a) Boilers 32,000,000 lbs/yr x 1,198 gals/lb = 3,900,000 gals/yr.

b) Cooling Wtr. 40 gpm x 60 min/hr x 24 hr/day x 365 days/yr. = 21,100,000 gals/yr.

c) Domestic Wtr. 525,000 gals/mo x 12 mos/yr = 6,300,000 gals/yr.

d) Maintenance Activities

20 gpm x 60 min/hr x 10 hrs/day x 4 days/wk x 52 wks/yr. = 2,500,000

e) Total = 33,800,00 gals/yr.

4) Leakage

63 water breaks repaired each year. 80% of these are on mains - remainder on service laterials and valves.

E M C ENGINEERS, INC.
2750 S. Wadsworth Blvd.
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Roswell, GA 30075
(404) 642-1864

JOB 1406.004 BAAP
SHEET NO. 1 OF 1
CALCULATED BY TCP DATE 4-18-95
CHECKED BY ______ DATE ______
SCALE ______

Reservoir Evaporation Rates

From Station Madison WSO (43°7' lat, 89°19' longitude):

Estimated Pan Evaporation = 40.46 in./year

Assume pan coefficient = 0.80 (shallow lake value)

Assume surface area of reservoir = 1.4 acre (scaled dwg.)

∴ Evaporation loss = (40.46 in/yr.)(0.8)(1.4 acre)

= 45.32 acre-in = 3.78 acre-ft.

Evaporation loss = (3.78 ac-ft)(325851 gal/ac-ft)

$\boxed{\text{Evaporation loss = 1,231,717 gal/yr.}}$

TO: MIKE SCHOLZ

985-2527

P 1 of 3

NOAA Technical Report NWS 34

Mean Monthly, Seasonal, and Annual Pan Evaporation for the United States

Washington, D.C.
December 1982

NOAA Technical Report NWS 33

Evaporation Atlas for the Contiguous 48 United States

Washington, D.C.
June 1982

STEFFEN ROBERTSON & KIRSTEN

News 34

TABLE II -- MONTHLY MEANS OF ESTIMATED "PAN EVAPORATION" COMPUTED FROM METEOROLOGICAL MEASUREMENTS USING A FORM OF THE PENMAN EQUATION*

	State No.	Station Index No.**	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	May-Oct***	Nov-Apr***	Annual***	Record Began Mo/Yr	Last Data Mo/Yr
WEST VIRGINIA (continued)																			
Elkins WSO 38° 55', 79° 49'	46	2718	0.99 10 24	1.21 10 25	2.23 10 19	3.14 10 14	4.33 11 12	4.39 11 10	4 8 ****	4 9 ****	3 9 ****	2 9 ****	1 9 ****	1 9 ****	22 ****	10 ****	32 ****	1/56	6/68
WISCONSIN																			
Green Bay WSO 44° 28', 88° 7'	47	3269	0.62 14 24	0.81 15 29	1.70 15 30	3.46 15 18	5.17 15 12	6.15 15 12	6.64 15 12	5.33 15 12	3.38 15 12	2.34 15 25	1.16 15 19	0.63 15 25	29.02 7	8.37 13	37.30 7	1/56	12/70
La Crosse WSO 43° 52', 91° 15'	47	4370	0.74 13 24	1.03 13 33	1.99 13 30	4.31 13 16	6.15 13 12	6.95 13 12	7.26 12 7	6.11 13 8	3.85 13 12	3.20 12 18	1.45 12 19	0.80 12 24	33.43 5	10.08 12	43.36 5	1/56	9/68
Madison WSO 43° 7', 89° 19'	47	4961	0.74 14 27	1.00 15 24	1.99 15 25	3.75 15 14	5.34 15 25	6.69 15 14	6.86 15 8	5.80 15 10	3.63 15 13	2.71 15 20	1.28 15 14	0.69 15 30	31.03 6	9.43 12	40.46 6	1/56	12/70
Milwaukee WSO 42° 56', 87° 53'	47	5479	0.85 15 24	1.09 15 26	2.01 15 30	3.82 15 14	5.57 15 18	6.70 15 13	7.23 15 13	5.96 15 12	4.04 15 11	2.88 15 19	1.55 15 13	0.90 15 19	32.39 7	10.22 12	42.62 6	1/56	12/70
WYOMING																			
Casper WSO 42° 55', 106° 28'	48	1570	1.85 15 25	1.92 15 23	3.03 15 27	4.73 15 18	6.92 15 12	8.76 15 16	10.64 15 10	9.85 15 6	6.65 15 13	5.18 15 41	2.38 15 19	1.82 15 24	48.01 7	15.73 7	63.74 5	1/56	12/70
Cheyenne WSO 41° 8, 104° 49'	48	1675	2.42 15 23	2.41 15 23	3.32 15 24	5.26 15 19	7.01 15 14	8.16 15 18	9.23 15 12	8.61 15 10	6.18 15 12	4.77 15 20	2.95 15 14	2.51 15 18	43.96 8	18.87 7	62.83 5	1/56	12/70
Lander WB Airport 42° 49', 108° 43'	48	5390	1.09 15 31	1.51 15 24	2.84 15 17	4.25 15 13	6.42 15 16	7.98 15 18	9.87 15 7	9.05 15 7	5.63 15 18	3.55 15 22	1.53 15 22	1.11 15 22	42.50 6	12.33 5	54.83 5	1/56	12/70
Sheridan WSO 44° 46', 106° 58'	48	8155	0.96 15 41	1.11 13 27	2.33 15 23	3.96 14 18	5.56 14 20	6.56 14 19	8.64 14 11	7.86 15 10	4.59 14 20	3.27 15 20	1.32 15 20	1.16 14 38	36.65 7	11.06 6	48.03 5	1/56	11/70

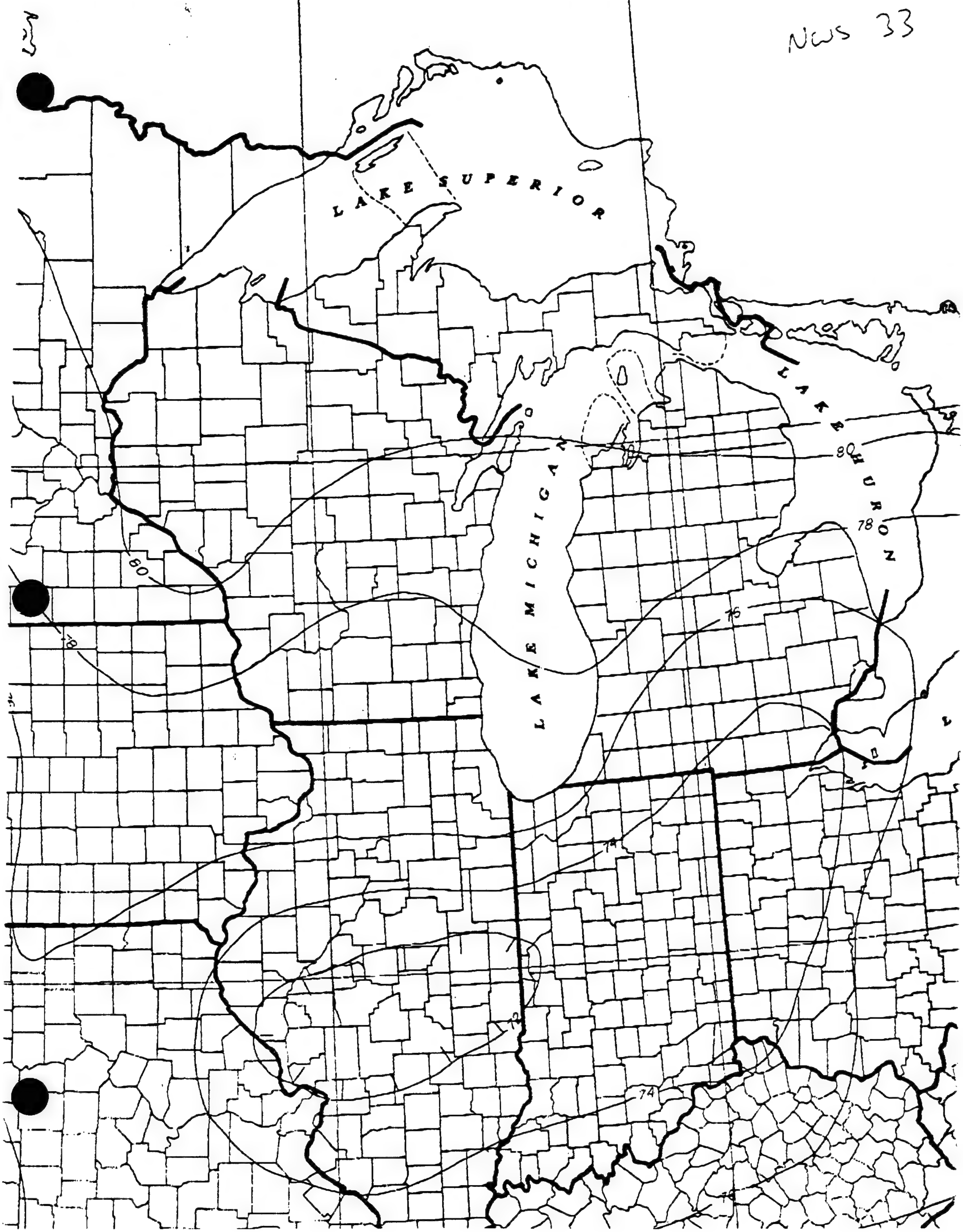
* First line of data in the table for each station is mean evaporation in inches; second line is the number of years of record per month; and third line is the coefficient of variation in percent (computed only when there are 10 years or more of record during 1956-1970).

** Climatological Data (NOAA-EDIS)

*** Sum of monthly means.

**** Insufficient data between 1956-70 to compute the coefficient of variation.

Nws 33


LAKE SUPERIOR
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LIFE CYCLE COST ANALYSIS SUMMARY
ENERGY CONSERVATION INVESTMENT PROGRAM (ECIP)

LOCATION:	Badger Army Ammunition Plant	REGION: 2 (Wisconsin)		PROJECT NO:	1406-004
PROJECT TITLE:	Leak Detection Study			FISCAL YEAR:	1995
ANALYSIS DATE:	05/09/95	ECONOMIC LIFE:	20	PREPARED BY:	T. Poeling

1. INVESTMENT: **ECO #2 - Reline BAAP-Designated Problem Piping**

A.	CONSTRUCTION COST	=	$647,032	
B.	SIOH COST	(6.0% of 1A) =	$38,822	
C.	DESIGN COST	(6.0% of 1A) =	$38,822	
D.	TOTAL COST	(1A +1B +1C) =	$724,676	
E.	SALVAGE VALUE OF EXISTING EQUIPMENT =		$0	
F.	PUBLIC UTILITY COMPANY REBATE =			
G.	TOTAL INVESTMENT	(1D -1E -1F) =	------->	$724,676

2. ENERGY SAVINGS (+) OR COST (-):
DATE OF NISTR 85-3273-9 USED FOR DISCOUNT FACTORS: JAN '95

	ENERGY SOURCE	FUEL COS $/KGAL (1)	SAVINGS KGAL/YR (2)	ANNUAL $ SAVINGS (3)	DISCOUNT FACTOR (4)	DISCOUNTED SAVINGS (5)	
A.	ELECT. (CURRENT)	$0.05	51,100	$2,402	15.88	$38,139	
B.	ELECT. (POTENTIAL)	$0.05	3,536	$166	15.88	$2,639	
C.	DIST	$5.00	0	$0	19.16	$0	
D.	NAT GAS	$4.00	0	$0	18.30	$0	
E.	COAL	$2.60	0	$0	16.62	$0	
G.	DEMAND SAV'GS (KW)	$6.82	0	$0	14.88	$0	
H.	TOTAL		54,636	$2,568		-------->	$40,778

3. NON-ENERGY SAVINGS (+) OR COST (-)

A. ANNUAL RECURRING (+/-)

1 WELL MAINTENANCE ($0.27/KGAL)	$14,752	14.88	$219,506
2 WATER DIST. MAINTENANCE ($1.22/KGAL)	$66,656	14.88	$991,840
3 CHEMICAL TREAT. SAVINGS ($0.032/KGAL)	$1,748	14.88	$26,015
4 TOTAL ANNUAL DISC. SAVINGS (+) / COST (	$83,156		$1,237,361

B. NON-RECURRING (+/-)

ITEM	SAVINGS (+) COST(-) (1)	YEAR OF CCURRENCE (2)	DISCOUNT FACTOR (3) (TABLE A-2)	DISCOUNTED SAVINGS/ COST (4)
a.				$0
b.				$0
c.				$0
d. TOTAL	$0			$0

C. TOTAL NON-ENERGY DISCOUNTED SAVINGS (+) OR COST (-) (3A4 + 3Bd4) = $1,237,361

4.	FIRST YEAR DOLLAR SAVINGS (+) / COSTS (-)	(2H3+3A+(3Bd1/Economic Life))	$85,724
5.	SIMPLE PAYBACK (SPB) IN YEARS (MUST BE < 10 YEARS TO QUALIFY)	(1G/4) =	8.45
6.	TOTAL NET DISCOUNTED SAVINGS	(2H5 + 3C) =	$1,278,139
7.	DISCOUNTED SAVINGS-TO-INVESTMENT RATIO (SIR) (MUST HAVE SIR > 1.25 TO QUALIFY)	(6/1G) =	1.76

ENGINEER'S OPINION OF PROBABLE COST

SHEET 1 OF 1

AREA	ACTIVITY	LOCATION	AMENDMENT NO.
Baraboo, Wisconsin	Leak Detection Study	Badger Army Ammunition Plant	

PROJECT TITLE	CONTRACT NO.
ECO #2 - RELINING PROBLEM PIPING AREAS	DACA01-94-D-0033

Line No.	Item Description	Unit of Measure	Qty.	MATERIAL COST Unit Cost	MATERIAL COST Total	LABOR COST Unit Cost	LABOR COST Total	EQUIPMENT COST Unit Cost	EQUIPMENT COST Total	TOTAL COST Unit Cost	TOTAL COST Total
1	**RELINING PIPING**										
2	EXCAVATION	CY	1,080	$0.00	$0	$1.48	$1,598	$1.51	$1,631	$2.99	$3,229
3	DEWATERING	DAY	2	$0.00	$0	$67.50	$135	$7.80	$16	$75.30	$151
4	PIPE LINING, 12" (14")	LF	6,720	$14.30	$96,096	$21.70	$145,824	$0.64	$4,301	$36.64	$246,221
5	PIPE LINING, 24"	LF	4,890	$18.30	$89,487	$28.60	$139,854	$0.84	$4,108	$47.74	$233,449
6	CRUSHED ROCK BEDDING	CY	360	$13.00	$4,680	$3.28	$1,181	$1.33	$479	$17.61	$6,340
7	BACKFILL	CY	720	$0.00	$0	$0.68	$490	$0.56	$403	$1.24	$893
8	COMPACTION	CY	1,080	$0.00	$0	$0.82	$886	$0.32	$346	$1.14	$1,231
9											
10											
11											
12											
13											
14											
15											
16											
17	**CONSTRUCTION SUBTOTAL**				$190,263		$289,967		$11,282		$491,513
18	LOCATION FACTOR	%		74.20%	$141,175	101.10%	$293,157	100.00%	$11,282		$445,615
19	OVERHEAD & BOND	%	20		$28,235		$58,631		$2,256		$89,123
20	SUBTOTAL				$169,410		$351,788		$13,539		$534,738
21	PROFIT	%	10		$16,941		$35,179		$1,354		$53,474
22	SUBTOTAL				$186,351		$386,967		$14,893		$588,211
23	CONTINGENCY	%	10		$18,635		$38,697		$1,489		$58,821
24	**GRAND TOTAL**				$204,986		$425,664		$16,382		$647,032

PREPARED BY	APPROVED BY	TITLE OR ORGANIZATION	DATE
TCP		E M C Engineers, Inc.	7/11/95

E M C ENGIN
2750 S. Wadsworth Blvd.
Suite C-200
Denver, CO 80227
(303) 988-2951

Response to Comment #5 BAAP

JOB 1406 004 BAAP
SHEET NO. ______ OF ______
CALCULATED BY TCP DATE 7-12-95
CHECKED BY ______ DATE ______
SCALE ECO #2 - LCCA

ECO #2 - Cost Comparison: Pipe Relining vs. Pipe Replacement

- All unit costs taken from Means Mechanical Cost Data (1995)
- Assume 24" diameter pipe

Relining Pipe (Per LF)

Item	Unit	Qty/LF	Unit Material	Unit Labor	Unit Equip.	Total
Excavation	CY	0.667	$0.00	$1.48	$1.51	$2.00
Pipe Lining	LF	1.0	$18.30	$28.60	$0.84	$47.74
Crushed Bedding	CY	0.222	$13.00	$3.28	$1.33	$3.91
Backfill	CY	0.445	$0.00	$0.68	$0.56	$0.55
Compaction	CY	0.667	$0.00	$0.82	$0.32	$0.76

Total/LF = $54.96

Replacing Pipe (Per LF)

Item	Unit	Qty/LF	Unit Material	Unit Labor	Unit Equip	Total
Excavation	CY	0.667	$0.00	$1.48	$1.51	$2.00
Pipe Removal	LF	1.0	$0.00	$4.09	$1.66	$5.75
Piping, 24"	LF	1.0	$45.50	$18.60	$4.32	$68.42
Crushed Bedding	CY	0.222	$13.00	$3.28	$1.33	$3.91
Backfill	CY	0.445	$0.00	$0.68	$0.56	$0.55
Compaction	CY	0.667	$0.00	$0.82	$0.32	$0.76

Total/LF = $81.39

A comparison of the piping for ECO #2 follows. The difference between replacing vs relining = $896,393 - $647,032 = $249,361

ENGINEER'S OPINION OF PROBABLE COST

SHEET	1	OF	1

AREA	ACTIVITY	LOCATION	AMENDMENT NO.
Baraboo, Wisconsin	Leak Detection Study	Badger Army Ammunition Plant	

PROJECT TITLE	CONTRACT NO.
ECO #2 - REPLACE PROBLEM PIPING AREAS (Alternative)	DACA01-94-D-0033

Line No.	Item Description	Unit of Measure	Qty.	MATERIAL COST Unit Cost	MATERIAL COST Total	LABOR COST Unit Cost	LABOR COST Total	EQUIPMENT COST Unit Cost	EQUIPMENT COST Total	TOTAL COST Unit Cost	TOTAL COST Total
1	**RELINING PIPING**										
2	EXCAVATION	CY	6,800	$0.00	$0	$1.48	$10,064	$1.51	$10,268	$2.99	$20,332
3	DEWATERING	DAY	4	$0.00	$0	$67.50	$270	$7.80	$31	$75.30	$301
4	PIPE REMOVAL, TO 24" DIA.	LF	6,720	$0.00	$0	$4.09	$27,485	$1.66	$11,155	$5.75	$38,640
5	PIPE REMOVAL, TO 24" DIA.	LF	4,890	$0.00	$0	$4.09	$20,000	$1.66	$8,117	$5.75	$28,118
6	PIPING, 14"	LF	6,720	$23.00	$154,560	$11.45	$76,944	$1.92	$12,902	$36.37	$244,406
7	PIPING, 24"	LF	4,890	$45.50	$222,495	$18.60	$90,954	$4.32	$21,125	$68.42	$334,574
8	CRUSHED ROCK BEDDING	CY	2,260	$13.00	$29,380	$3.28	$7,413	$1.33	$3,006	$17.61	$39,799
9	BACKFILL	CY	4,540	$0.00	$0	$0.68	$3,087	$0.56	$2,542	$1.24	$5,630
10	COMPACTION	CY	6,800	$0.00	$0	$0.82	$5,576	$0.32	$2,176	$1.14	$7,752
11											
12											
13											
14											
15											
16											
17	**CONSTRUCTION SUBTOTAL**				$406,435		$241,793		$71,323		$719,551
18	LOCATION FACTOR	%		74.20%	$301,575	101.10%	$244,453	100.00%	$71,323		$617,351
19	OVERHEAD & BOND	%	20		$60,315		$48,891		$14,265		$123,470
20	SUBTOTAL				$361,890		$293,343		$85,588		$740,821
21	PROFIT	%	10		$36,189		$29,334		$8,559		$74,082
22	SUBTOTAL				$398,079		$322,677		$94,147		$814,903
23	CONTINGENCY	%	10		$39,808		$32,268		$9,415		$81,490
24	**GRAND TOTAL**				$437,887		$354,945		$103,561		$896,393

PREPARED BY	APPROVED BY	TITLE OR ORGANIZATION	DATE
TCP		E M C Engineers, Inc.	7/11/95

E M C ENGINEERS, INC.
2750 S. Wadsworth Blvd. Suite C-200 Denver, CO 80227 (303) 988-2951
9755 Dogwood Rd. Suite 220 Roswell, GA 30075 (404) 642-1864

JOB BAAP 1486-004
SHEET NO. 1 OF 1
CALCULATED BY TLP DATE 5-2-95
CHECKED BY ______ DATE ______
SCALE ECO #2 - LCCA

ECO #2 - Rehabilitate BAAP Designated Problem Areas

Four sections of pipe were designated by BAAP as having excessive historical leakage. Those piping sections designated, total length, and nearest shutoff valve are:

Priority 1: 24" line
From Valve #281 (N16905, E3013)
To Valve #F-11 (N14461, E3013)
Ø leaks surveyed
Total Length = 2,244 ft
Total number of (service) branches = 12
(8 serve Caretaker Areas)

Priority 2: 24" line
From Valve #368 (N16400, E2020)
To Valve #F-9 (N13756, E2023)
Ø leaks surveyed
Total Length = 2,644 ft
Total number of (service) branches = 10
(6 serve Caretaker areas)

Priority 3: 14" line
From Valve #268 (N16765, E4885)
To Valve #341 (N13894, E4885)
2 leaks surveyed at 70,000 gpd
Total Length = 2,870 ft
Total number of (service) branches = 38

Priority 4: 14" line
From Valve #204 (N21109, E4245)
To Valve #242 (N18670, E4215)
2 leaks surveyed @ 70,000 gpd
Total Length = 2,440 ft
Total number of (service) branches = 22

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ECO #2 - Relining Pipe w/ Cement

Rehabilitation costs based on combination of Means Mechanical Cost Data, bids for relining projects at BAAP in 1990, and case studies from AWWA.

According to Means Mechanical (1994), lining pipe including bypass and cleaning, for rural areas (10,000 LF or greater)

	Material	Labor	Equip.	Total
14" pipe	$7.15	$10.85	$0.32	$18.32/LF
24" pipe	$9.15	$14.30	$0.42	$23.87/LF

According to 1990 bid for 4,300 L.F. of 24" pipe and 1,200 L.F. of 14" pipe. (5,500 LF total)

Bids received:

• Mainline Service	$306,290	($56/LF)
• Spinello Construction	$185,000	($34/LF)
• W. Walsh Co.	$371,140	($68/LF)

Case Studies from "Assessment of Existing and Development of Water Main Rehabilitation Practices (1990)"

- Washington Suburban Sanitary Commission = $27-28/LF (avg.)
- Los Angeles Dept. of Water/Power = $27/LF (1987)
- Table 7.3 (pg. 114) "Comparison of Contractor Cost for Various Rehabilitation Techniques" lists for cleaning + cement lining (18" < x < 32") typical cost = $22-58

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ECO #2 - Relining Pipe w/ Cement

Rehabilitation costs have been taken from 1990 bids and 1987 Reports. What is the present worth of those values today (1995)?

Assume: Inflation rate = 4%
For periods of 5 yrs and 8 yrs.

Therefore: $F_{1995} = P_{1990}$ (F/P, 4%, 5 yrs) =

From interest tables, (F/P, 4%, 5 yrs) = 1.2167
(F/P, 4%, 8 yrs) = 1.3686

Listing of Cement Lining Prices (1995 prices)

Location	Year of Study	Cost	1995 Cost
Means Mechanical	1994	-	$23.87/LF
Washington Suburban	1987	$28/LF	$38.32/LF
L.A. Dept. of Water	1987	$27/LF	$36.95/LF
Spiniello Construction	1990	$34/LF	$41.37/LF
Mainline Service	1990	$56/LF	$68.14/LF
W. Walsh Co.	1990	$68/LF	$82.74/LF
			$291.39/LF

Mean Cost (Avg.) = $48.55/LF
Median Cost = $40/LF

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ECO #2 - Cost Estimate

Another reason that rehabilitating piping is more economical than replacing piping is that the entire length of piping does not need to be excavated. Only access points need to be excavated.

Assume access points are required every ≈ 500 ft:

- Priority 1 - Length = 2,244 ft. ⇒ Assume 4 access pts.
- Priority 2 - Length = 2,644 ft. ⇒ Assume 5 access pts.
- Priority 3 - Length = 2,870 ft. ⇒ Assume 6 access pts.
- Priority 4 - Length = 2,440 ft. ⇒ Assume 5 access pts.

Total: 20 access pts.

- Excavate: (9 yds L) × (3 yds W) × (2 yds D) = 54 yds ea.
  Total excavation = (20 pts)(54 yds ea) = 1,080 CY
- Backfill bedding: (9 yds L) × (3 yds W) × (2/3 yd D) = 18 yds ea.
  Total bedding: (20 pts)(18 yds ea) = 360 CY
- Backfill soil: 1080 CY - 360 CY = 720 CY

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ECO #2 - Cost Estimate (cont)

For pipe replacement, the entire length of pipe must be excavated and backfilled, thus increasing costs.

Excavation

Assume excavating 3' W × 6' D = 18 CF/LF piping
= 0.667 CY/LF

For total length = 10,200 L.F., total excavation = 6,800 C.Y.

Backfill - Bedding

Assume bedding 3' W × 2' D = 6 CF/LF piping
= ~~0.333~~ 0.222 CY/LF

For total length = 10,200 LF, total bedding = 2,260 CY

Backfill - Soil

Backfill is difference between excavation + bedding backfill

Backfill (Soil) = 6,800 - 2,260 = 4,540 CY

ENGINEER'S OPINION OF PROBABLE COST

SHEET 1 **OF** 1

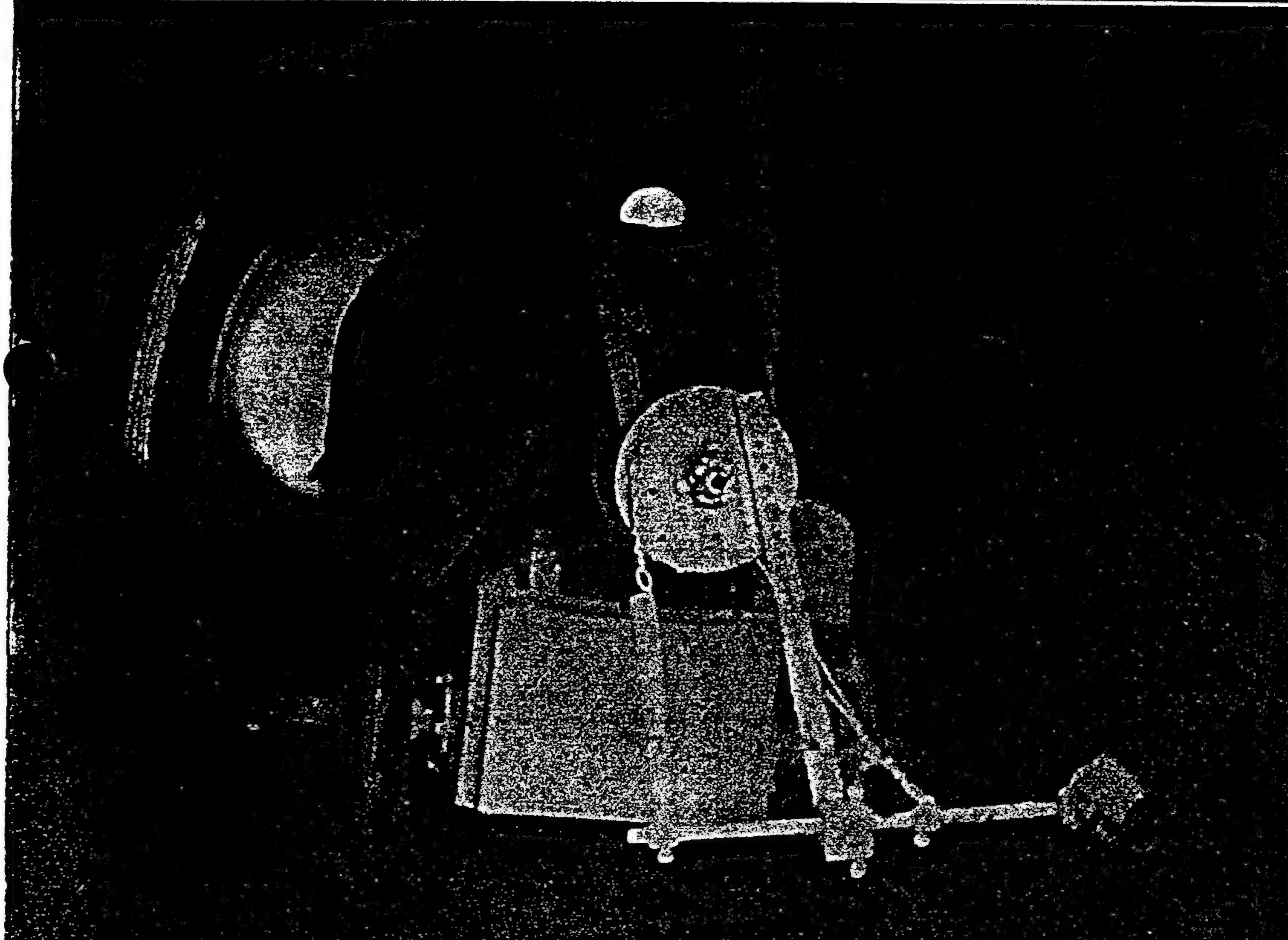
AREA	**ACTIVITY**	**LOCATION**	**AMENDMENT NO.**
Baraboo, Wisconsin	Leak Detection Study	Badger Army Ammunition Plant	

PROJECT TITLE	**CONTRACT NO.**
ECO #2 - REPLACE PROBLEM PIPING AREAS (Alternative)	DACA01-94-D-0033

Line No.	Item Description	Unit of Measure	Qty.	MATERIAL COST Unit Cost	MATERIAL COST Total	LABOR COST Unit Cost	LABOR COST Total	EQUIPMENT COST Unit Cost	EQUIPMENT COST Total	TOTAL COST Unit Cost	TOTAL COST Total
1	**RELINING PIPING**										
2	EXCAVATION	CY	6,800	$0.00	$0	$1.48	$10,064	$1.51	$10,268	$2.99	$20,332
3	DEWATERING	DAY	4	$0.00	$0	$67.50	$270	$7.80	$31	$75.30	$301
4	PIPE REMOVAL, TO 24" DIA.	LF	6,720	$0.00	$0	$4.09	$27,485	$1.66	$11,155	$5.75	$38,640
5	PIPE REMOVAL, TO 24" DIA.	LF	4,890	$0.00	$0	$4.09	$20,000	$1.66	$8,117	$5.75	$28,118
6	PIPING, 14"	LF	6,720	$23.00	$154,560	$11.45	$76,944	$1.92	$12,902	$36.37	$244,406
7	PIPING, 24"	LF	4,890	$45.50	$222,495	$18.60	$90,954	$4.32	$21,125	$68.42	$334,574
8	CRUSHED ROCK BEDDING	CY	2,260	$13.00	$29,380	$3.28	$7,413	$1.33	$3,006	$17.61	$39,799
9	BACKFILL	CY	4,540	$0.00	$0	$0.68	$3,087	$0.56	$2,542	$1.24	$5,630
10	COMPACTION	CY	6,800	$0.00	$0	$0.82	$5,576	$0.32	$2,176	$1.14	$7,752
11				$0	$0	$0	$0	$0	$0	$0.00	$0
12				$0	$0	$0	$0	$0	$0	$0.00	$0
13											
14											
15											
16											
17	**CONSTRUCTION SUBTOTAL**				$406,435		$241,793		$71,323		$719,551
18	LOCATION FACTOR	%		**74.20%**	$301,575	**101.10%**	$244,453	**100.00%**	$71,323		$617,351
19	OVERHEAD & BOND	%	20		$60,315		$48,891		$14,265		$123,470
20	SUBTOTAL				$361,890		$293,343		$85,588		$740,821
21	PROFIT	%	10		$36,189		$29,334		$8,559		$74,082
22	SUBTOTAL				$398,079		$322,677		$94,147		$814,903
23	CONTINGENCY	%	10		$39,808		$32,268		$9,415		$81,490
24	**GRAND TOTAL**				$437,887		$354,945		$103,561		$896,393

PREPARED BY	**APPROVED BY**	**TITLE OR ORGANIZATION**	**DATE**
TCP		E M C Engineers, Inc.	5/2/95

Cleaning and cement lining of water mains

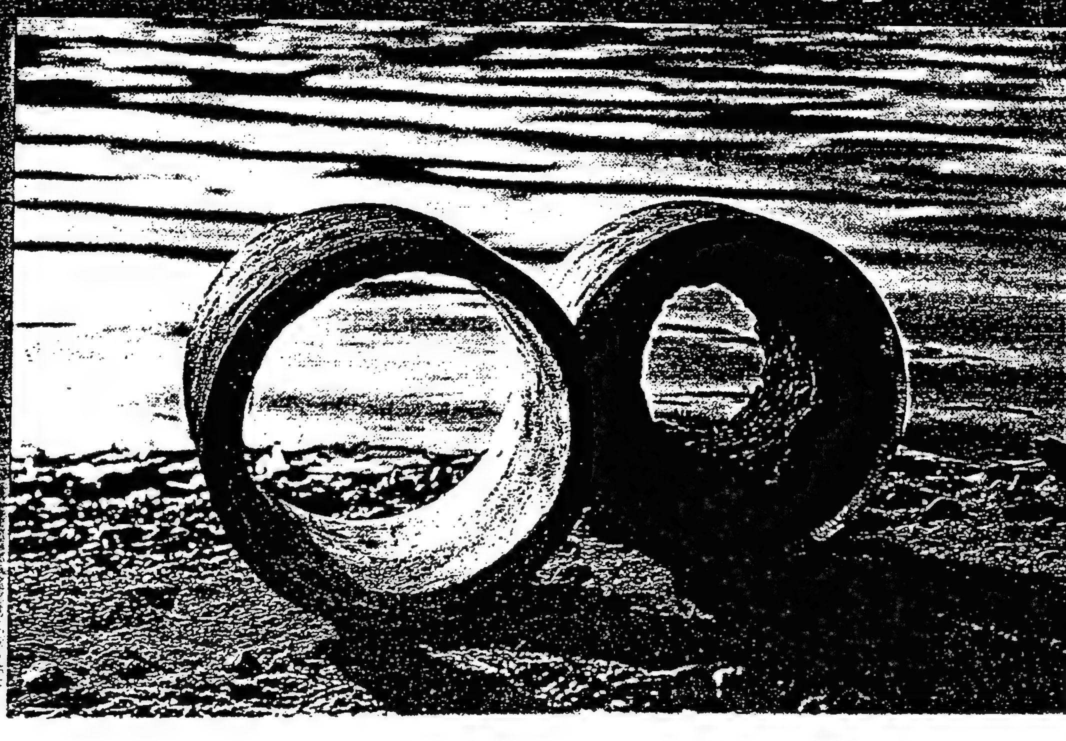


(3)

The advantages of cement mortar lining in-place:

- Permanently increases carrying capacity
- Reduces pumping costs
- Prevents corrosion in steel and cast iron pipe
- Stops leakage
- Increases life of pipe
- Best protection for new steel pipelines
- Eliminates red water
- Raises distribution pressure
- Helps maintain chlorine residual

All at a fraction of the cost for new pipelines!



The W. Walsh Company, a specialized construction organization, offers years of experience in providing turnkey construction projects. We have successfully rehabilitated hundreds of thousands of feet of pipeline by in-place cleaning and cement mortar lining. From initial design through project completion, our engineers and technicians remain deeply involved to ensure that each job is technically correct and free of inconveniences. Client satisfaction has been, and continues to be, the basis of our success.

We're headquartered in Massachusetts, yet our contracts span the entire United States, South America and off-shore islands.

We are proud of our role in helping to renew the water supply infrastructure of American cities, towns and industry.

In-place cement mortar linings

Rehabilitation of pipelines in-place by the centrifugal method dates back to the early 1900s. Equipment improvements now allow pipelines from 4" to 144" to be cleaned and lined economically.

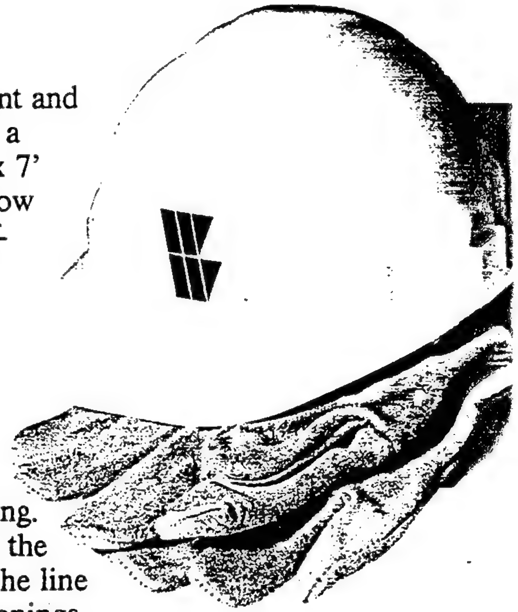
Chemical & physical properties

The protection provided by the lining is due to two properties of the cement itself. First, there is the alkaline mortar reaction and, secondly, there is a gradual decrease in the amount of water in contact with the pipe wall. The highly alkaline condition at the pipe wall eventually becomes static because the chemical reaction of the cement, air and water tend to clog the porous cement. Thus, the lining provides a physical as well as chemical protection.

The linings stay in place because of the arch action inherent in the cement lining. Once the lining has hardened, it forms a continuous arch—a pipe within a pipe.

Convenience during construction

We install an above ground bypass distribution system to serve customers affected by the cleaning and lining project. Two inch, four inch, six inch or larger pipe is provided to ensure proper domestic service and fire protection. Bypass lines are buried where neces-



Pipeline access

Excavations for equipment and material access are held to a minimum. Normally, a 5' x 7' excavation, to one foot below pipe level every 500' is sufficient. Holes are covered with steel plates except when crews are working at the location.

Cleaning

The buildup of tuberculation is removed either by hydraulic or drag cleaning. With the hydraulic method, the cleaner is pushed through the line by water pressure. The cleanings are discharged into a receptacle and removed from the site. This method is used when volume and system pressure permit.

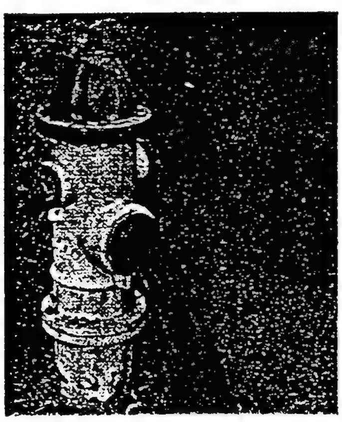
When hydraulic cleaning is not practical, the drag technique is employed. Here the cleaning devices are winched back and forth through the lines, until they are suitably clean. In some instances, this method is water assisted to flush out debris as the cleaner scrapes the pipe wall clean.

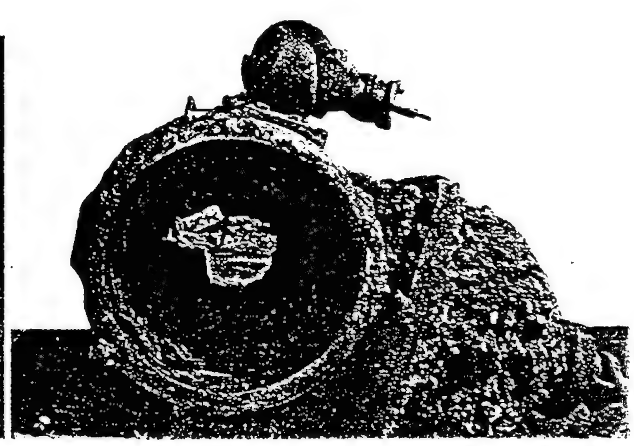
Cement Mortar Lining

A mortar consisting of a 1 to 1 mix of sand and cement is conveyed either by mechanical vehicle or a constant displacement pump to the lining machine. The mortar is extruded through finger plates on the lining machine, picked up by the rapidly rotating head and centrifugally discharged onto the pipe wall. The thickness of the lining is governed by the speed of the lining machine as well as the extrusion rate of the mortar. Conical trowels for smaller diameter pipe and rotating trowels for larger diameter pipe finish the lined surface to ensure optimum hydraulic efficiency. Services are cleaned by back flushing with air or water before the mortar sets. Ends of the pipeline are immediately closed to ensure proper curing.

The results

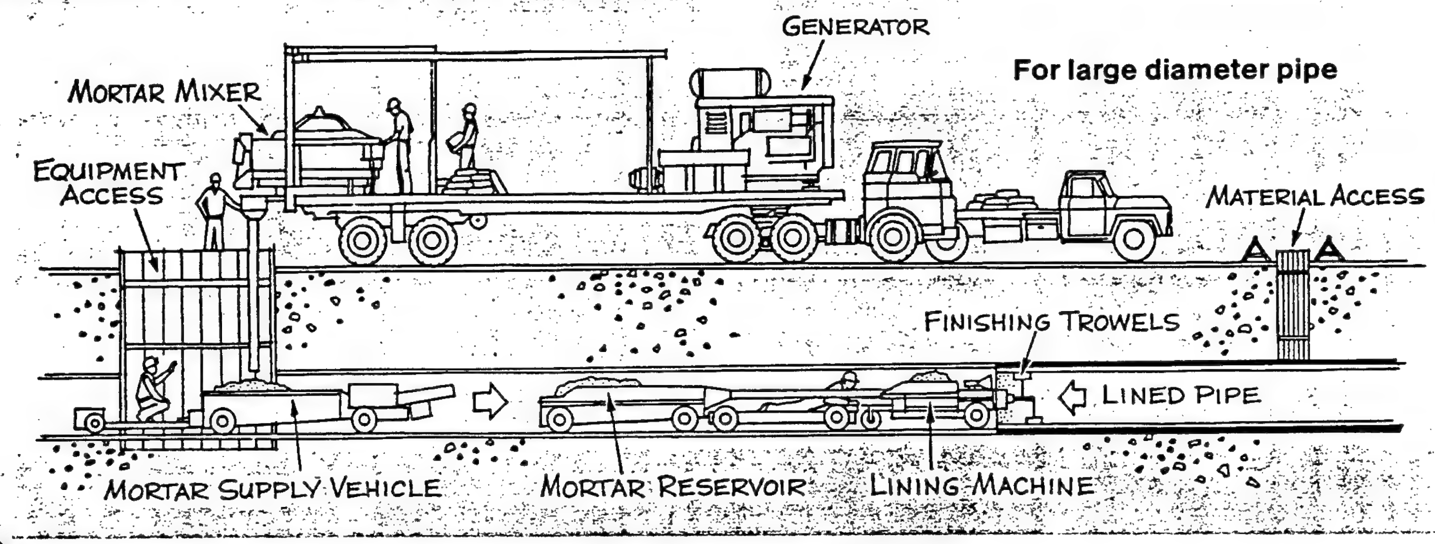
A hydraulically efficient, long lasting pipeline at a fraction of the cost and inconvenience of replacement.

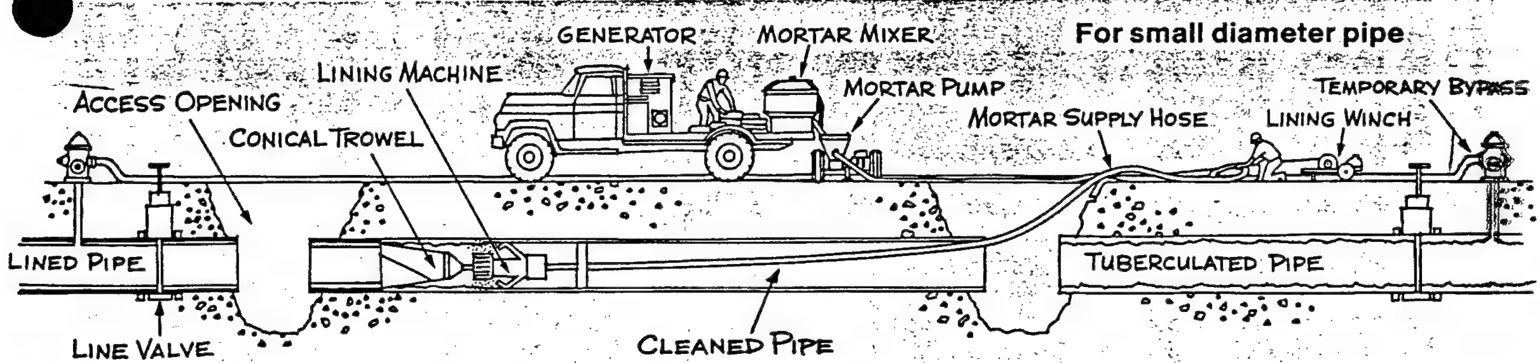




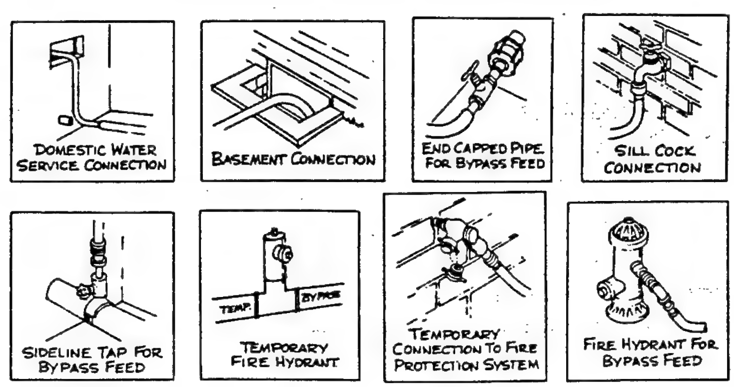
Turnkey economy for rehabilitated pipelines.

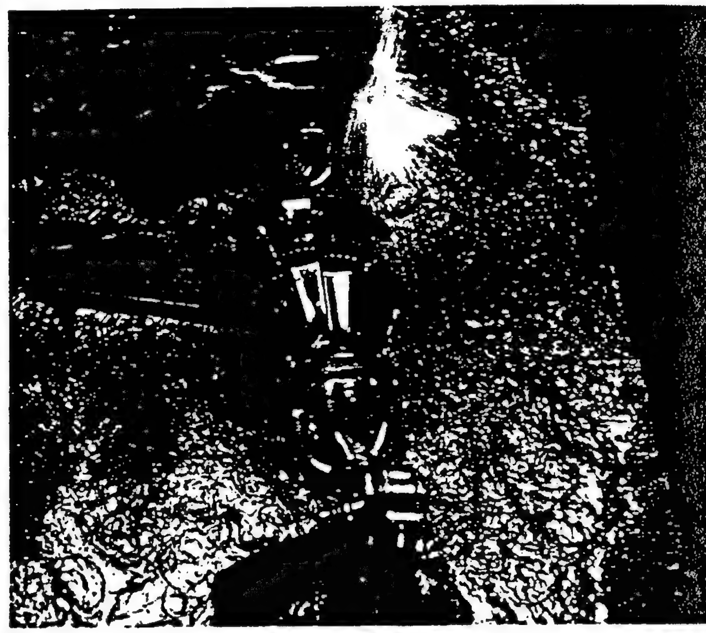
Our work conforms to AWWA Specifications C602, C205.



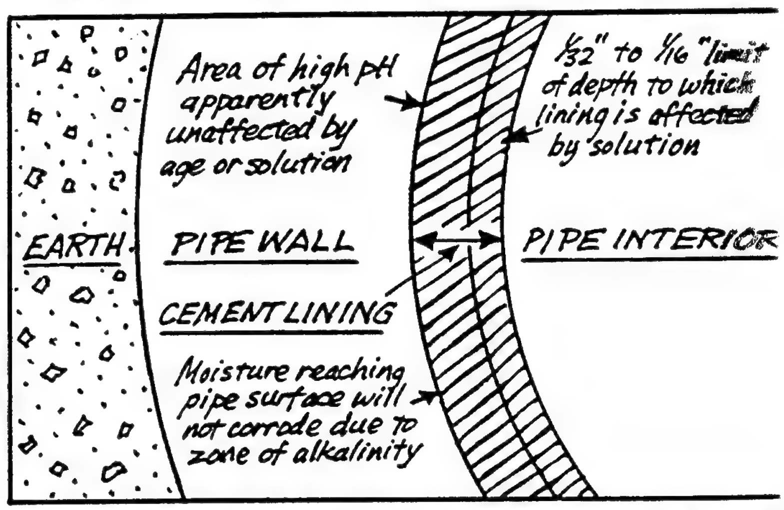


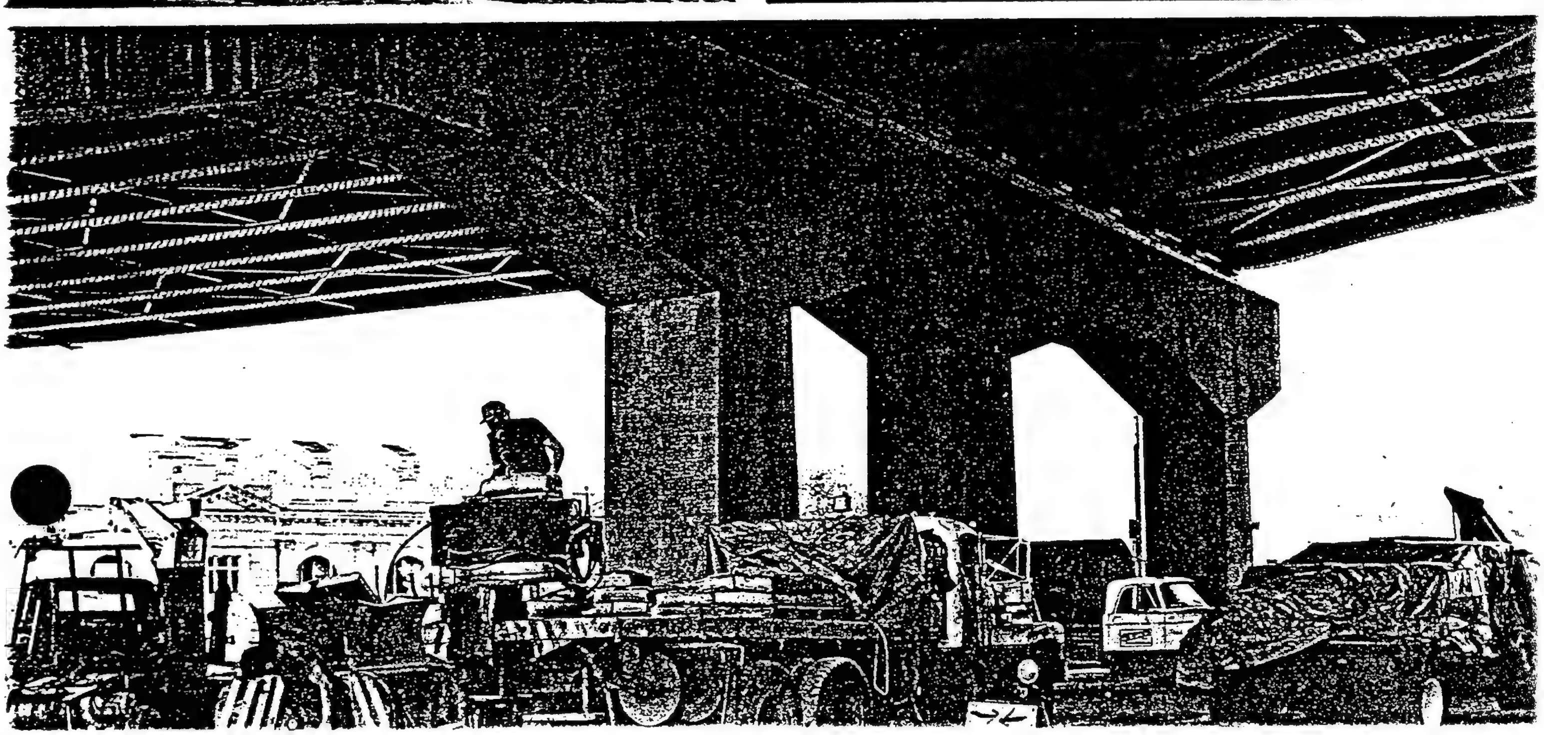
TYPICAL BY-PASS TECHNIQUES





ZONE OF ALKALINITY IN CEMENT-MORTAR LINING





PART I

STATEMENT OF WORK

Repair Old Acid Area Watermains

SW-1 WORK TO BE ACCOMPLISHED

A. This project consists of relining a total of approximately (Contractor to verify) 4,300 lineal feet of 24" diameter steel watermains and 1,200 lineal feet of 14" diameter steel water mains. The exact location of water mains to be relined are shown on drawing SK-4373. All in accordance with AWWA C-602.

All work will be done in a workmanlike manner using all the latest methods and procedures to insure that the work is done according to plans and specifications.

The present water line will be shut off and reopened by Olin personnel.

The installation of cement lining will be done according to the following procedure.

1. Excavation

All excavation of every description and of whatever substances encountered shall be performed to the depths indicated or as otherwise specified. During excavation, material suitable for backfilling shall be piled in an orderly manner a sufficient distance from the banks of the trench to avoid overloading and to prevent slides or cave-ins. All excavated materials not required or suitable for backfill shall be removed and wasted as specified. Grading shall be done as may be necessary to prevent surface water from flowing into trenches or other excavations and any water accumulated therein shall be removed by pumping or by other approved methods. Sheeting and shoring shall be placed as may be necessary for the protection of the work and for the safety of personnel. Unless otherwise indicated, excavation shall be by open cut.

2. Cleaning

The entire procedure for cleaning, repairing and lining the mains, selection of points of access, sequence of operations, and other features of the work shall be determined by the Contractor, subject to the approval of the Contracting Office. All rust, tubercles, deposits, disintegrated coatings and other foreign materials shall be removed from the inside of the pipe by the Contractor using approved methods which will produce a

satisfactory surface for the application of the cement-mortar lining. More than one passage of the cleaning machine through the pipe shall be made if required to produce the specified results. Suitable provisions shall be made to prevent damage to adjacent structures or paving by water used for cleaning the pipe, and the Contractor shall be responsible for such damage. At the conclusion of the cleaning operations, nothing shall remain on interior pipe line surfaces which would be harmful to the cement-mortar lining, or which would inhibit or destroy its bond. The Contractor shall inspect the cleaned pipe and repair all visible holes and defects. Hand scrapers, hand or machine operated wire brushes, or other approved methods shall be used, if required, to prepare pipe surface for the proper application of the lining. However, it is not the intention of these specifications to require a bare surface as would be obtained by shot blasting. Hand cleaning will be required at the ends of the sections specified to be lined, the amount depending upon the locations selected for the openings to be cut for the insertion and removal of the cleaning equipment. The Contractor shall impound water discharged from the section of the main being cleaned, to settle the dislodged particles and sludge. The overflow from impoundments shall be ditches and drains as directed by Olin Engineering; however, the Contractor shall be responsible for any damage to streets, curbs or other structures caused by cleaning water. The material settled out in the impoundments shall be disposed of by the Contractor at a location designated by Olin Engineering.

3. <u>Protection of Connections</u>

Before placing the lining, openings in the pipe leading to connecting branches, blow offs, valves and other appurtenances shall be temporarily covered or plugged by the Contractor with satisfactory stoppers or sealed by other approved methods so that the cement mortar will not be thrown into these openings. The locations of all such openings shall be carefully noted, all plugs, covers or temporary stoppers shall be removed, any necessary patching done, and the lining neatly finished around each opening or appurtenance. At the same time, any other patching or finishing, including the lining at temporary openings and holes, shall be done. All edges of lining at ends of lined sections shall be neatly finished. Edges shall be rounded so as to avoid sharp angles or abrupt changes in section which may tend to cause failure of the lining or offer resistance to flow. Where sections of pipe are to be cut out and replaced, the lining of these sections may be done while removed, or after they have been replaced. Where the pipe diameter is insufficient or other conditions prevent the placement of temporary covers or plugs, connections to the pipe line shall be back-flushed with water or blown out with air as soon as practical after the lining has been placed to remove all mortar from the connections.

4. Lining Placement

The cement-mortar lining shall be continuous, dense, and without variation in quality. The thickness shall not be less than 1/4", nor more than 7/16" except at tees, connections, and other fittings where the thickness may be less, providing the change in thickness is not noticeable abrupt. The lining shall consist of a one-course application of cement mortar applied by a machine which projects the mortar against the wall of the pipe by centrifugal action, with sufficient velocity to cause the mortar to be densely packed and to adhere to the pipe surface. The travel of the machine and the rates of discharge of mortar shall be controlled so as to produce a uniform thickness of lining around the perimeter and along the length of the pipe. Hand placing of lining will be permitted only adjacent to valves, at bends in the pipe, adjacent to specials, or at other points where machine placing is impossible or impractical. The machine shall be provided with an attachment for mechanically troweling the freshly placed mortar to produce a smooth surface finish. The design of the trowel attachment shall be such as to permit operation in pipes which may be slightly out of round. All waste materials and spatter shall be removed from the pipe ahead of the trowel. Only mortar of suitable consistency and applied with sufficient velocity to adhere firmly to the surface of the pipe shall be finally troweled to form the lining. If marks of the trowel are excessively obvious, or if the machine should fail to produce a smooth surface of uniform thickness at any point, then hand troweling shall be done as soon as practicable after the application of the machine lining. Fresh mortar shall be used to fill any voids or porous spots in the lining. If any section of the lining shows evidence of failure, unusual or undue irregularity, or shall require an excessive amount of patching, the faulty section of lining shall be removed to the extent directed by Olin Engineering, the pipe recleaned and the lining replaced. The Contractor shall make determinations of the thickness of the lining as Olin Engineering may direct in order to maintain proper control of application operations. After the lining is completed, the Contractor shall remove any mortar or debris that may have lodged in valves or appurtenances. Any damage to the main, connections, fire hydrant leads, etc., caused by the cleaning or lining operation or due to the negligence of the Contractor, shall be repaired by the Contractor at his own expense.

5. Curing and Protection of Lining

Immediately upon completion of the lining of a length of pipe, or of a day's run of the lining machine, that section of pipe shall be closed at each end and openings covered to prevent circulation of air. As soon as practicable after placing the lining, water shall be introduced into the section between bulkheads or valves in order to create a moist atmosphere and keep the lining damp. Every precaution shall be taken to prevent injury to the lining. Should it be damaged by fault of the Contractor or reveal evidence of defective work or materials at any time previous to completion of the contract, such damage or defective portions shall be removed to the extent directed and replaced to the satisfaction of Olin Engineering. The intention of these specifications is to assure a dense, homogeneous and smooth lining. Upon completion of the work and before filling and disinfection all fragments of mortar and other debris shall be removed by the Contractor, leaving the pipe clean and ready for use.

6. Access Openings

Access openings shall be constructed by either cutting a spool from the pipe or removing the upper half of the pipe. Pipe spools for access to the interior of the pipe lines shall be cut only in the straight lengths of pipe. Care shall be taken in removing the spools to insure neat square edges, so that the sections removed can be readily replaced. The spools shall be cleaned and lined in accordance with the specifications for the main lengths of pipe line. As soon as a section of the main has been cleaned, lined, and inspected, the Contractor shall replace the spool or half-cap section with couplings or by welding. Couplings shall conform to "Watermains" except that couplings for steel lines may be constructed of steel. Before the access excavation is backfilled, full normal water pressure shall be applied to that section of the pipe line and if the couplings or welds leak, they shall be repaired and retested until proven drip-tight. Couplings shall be protected with the manufacturer's standard coating. Couplings and welds shall be protected by a coal tar coating at least 1/8" thick applied after installation. The ends of pipes to be joined with couplings or welds shall be cleaned and smoothed, and couplings shall be installed in strict accordance with the manufacturer's recommendations.

7. Clearing Obstructions

Obstructions shall be defined as any bend, fitting, restricting special valve, or physical restriction not shown by the contract drawings, which will not permit passage of the Contractor's cleaning and/~~or cement~~-mortar lining equipment, and which requires exposing the pipe line at the location of the restriction and the cutting of the pipe in two or more places for its effective removal or correction. In the event that obstructions are found, a report thereof shall be made to Olin Engineering.

8. Disinfection

Newly lined water pipe lines shall be disinfected in accordance with AWWA C-601.

9. Clean Up

Upon completion of the water pipe line lining operation all debris and surplus materials resulting from the work shall be removed.

B. Leaks (holes) in the existing piping will be repaired by welding a patch placed over the holes or other approved methods.

C. Backfill of excavation will be done with washed sand placed 12" thick around entire pipe, leveled, and compacted. The remainder of the trench shall be filled with native material removed and compacted to 95% compaction in 12" lifts. All construction areas will be repaired to an as-built condition.

D. All debris will be hauled to the landfill as directed by Olin Engineering.

Bid 1/30/1990

RAYMOND INTERNATIONAL BUILDERS 365 PASSIAC STREET ROCHELLE, NY 07662	None
MAINLINE SERVICE P. O. BOX 96 ELMA, NY 14059	$306,290-
AMERON PIPE LINING DIVISION 360 CARNEGIE AVENUE P. O. BOX 67 KENILWORTH, NJ 07033	None
SPINIELLO CONSTRUCTION COMPANY 25 AIRPORT ROAD MORRISTOWN, NJ 07960	$185,000-
AMERON PIPE LINING DIVISION P. O. BOX 22613 LONG BEACH, CA 90801-5613	None
W. WALSH COMPANY, INC. 32 WALTON STREET ATTLEBORO, MA 02703	$371,140-
HEITKAMP, INC. 99 CALLENDAR ROAD P. O. BOX 730 WATERTOWN, CT 06795	None

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ECO #3 - Isolate Specific Caretaker Areas

This ECO identifies areas that are classified as Caretaker. Savings for this ECO should be quantified not only by the amount of current leakage saved, but also on the potential future leakage that will be saved. Assume all perimeter fire hydrants branches (6") which are connected to main lines will remain.

① Isolate Area #8 (E-Line NC) - ECO #3A

Need to isolate: Valve #193 (24")
" #322 (16")
" #324 (16")
" #336 (16")
" #338 (24")

Saves 2 leaks (valves) 2,750 gpd currently (as of leak survey)

② Isolate Area #1 - (Old Acid Area) - ECO #3B

Isolate Line E1591 (24") at following locations:

Valve #238 (24")
" #254 (24")
" #257 (24")

Saves hydrant #11 (750 gpd) leakage as of leak survey.

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JOB 1406.004 BAAP

CALCULATED BY TCP DATE 1-10-95

CHECKED BY ______ DATE ______

SCALE ECO #3 LCCA

ECO #3 (cont)

(3) Isolate Area #12 (D Line SB) - ECO #3C

Isolate: Valve #308 (10")
" #309 (16")
" #310 (16")
PRV at Coordinate N15,985 and East 3,092 (10")

Saves one main line leak + one service leak (6,000 gpd) as of leak detection survey.

(4) Isolate Area #13 (E Line SB) - ECO #3D

Isolate: Valve #325 (16")
" #326 (16")
" #334 (24")
" #337 (24")
PRV at Coordinate N14,940 and E3,090 (10")
PRV at Coordinate N14,945 and E3,760 (10")

Currently there is no leakage in this area

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ECO #3 (Cont)

⑤ Isolate Area #9 (F Line NC) - ECO #3E

Isolate:	Valve	#F-1	(16")
		#F-3	(16")
		#F-4	(24")
		#F-6	(16")

Currently no leakage in this area.

⑥ Isolate Area #18 (Rocket East) - ECO #3F

Isolate:	Valve	#41	(16")
	"	#45	(16")
	"	#48	(16")
	"	#51	(16")
	"	#52	(12")
	"	#104	(12")
	"	#135	(16")
	"	#137	(12")
	"	#138	(16")
	"	#138A	(12")
	"	#162	(16")

Saves leakage at hydrant #640, #592 and Valve #162 (total = 3,500 gpd) as of leak detection survey.

LIFE CYCLE COST ANALYSIS SUMMARY

ENERGY CONSERVATION INVESTMENT PROGRAM (ECIP)

LOCATION: Badger Army Ammunition Plant REGION: 2 (Wisconsin) PROJECT NO: 1406-004

PROJECT TITLE: Leak Detection Study FISCAL YEAR: 1995

ANALYSIS DATE: 05/09/95 ECONOMIC LIFE: 20 PREPARED BY: T. Poeling

1. INVESTMENT: **ECO #3 - Isolate 'Caretaker' Areas**

A.	CONSTRUCTION COST	=	$63,753	
B.	SIOH COST	(6.0% of 1A) =	$3,825	
C.	DESIGN COST	(6.0% of 1A) =	$3,825	
D.	TOTAL COST	(1A +1B +1C) =	$71,403	
E.	SALVAGE VALUE OF EXISTING EQUIPMENT	=	$0	
F.	PUBLIC UTILITY COMPANY REBATE	=		
G.	TOTAL INVESTMENT	(1D -1E -1F) =	------->	$71,403

2. ENERGY SAVINGS (+) OR COST (-):

DATE OF NISTR 85-3273-9 USED FOR DISCOUNT FACTORS: JAN '95

	ENERGY SOURCE	FUEL COST $/KGAL (1)	SAVINGS GAL/YR (2)	ANNUAL $ SAVINGS (3)	DISCOUNT FACTOR (4)	DISCOUNTED SAVINGS (5)	
A.	ELECT. (CURRENT)	$0.05	4,745	$223	15.88	$3,541	
B.	ELECT. (POTENTIAL)	$0.05	13,987	$657	15.88	$10,439	
C.	DIST	$5.00	0	$0	19.16	$0	
D.	NAT GAS	$4.00	0	$0	18.30	$0	
E.	COAL	$2.60	0	$0	16.62	$0	
G.	DEMAND SAV'GS (KW)	$6.82	0	$0	14.88	$0	
H.	TOTAL		18,732	$880		-------->	$13,981

3. NON-ENERGY SAVINGS (+) OR COST (-)

A. ANNUAL RECURRING (+/-)

	ANNUAL $	DISCOUNT FACTOR	DISCOUNTED SAVINGS
1 WELL MAINTENANCE ($0.27/KGAL)	$5,058	14.88	$75,258
2 WATER DIST. MAINTENANCE ($1.22/KGAL)	$22,853	14.88	$340,053
3 CHEMICAL TREAT. SAVINGS ($0.032/KGAL)	$599	14.88	$8,919
4 TOTAL ANNUAL DISC. SAVINGS (+) / COST (-	$28,510		$424,230

B. NON-RECURRING (+/-)

ITEM	SAVINGS (+) COST(-) (1)	YEAR OF CCURRENCE (2)	DISCOUNT FACTOR (3) (TABLE A-2	DISCOUNTED SAVINGS/ COST (4)
a.				$0
b.				$0
c.				$0
d. TOTAL	$0			$0

C. TOTAL NON-ENERGY DISCOUNTED SAVINGS (+) OR COST (-) (3A4 + 3Bd4) = $424,230

4.	FIRST YEAR DOLLAR SAVINGS (+) / COSTS (-)	(2H3+3A+(3Bd1/Economic Life))	$29,391
5.	SIMPLE PAYBACK (SPB) IN YEARS (MUST BE < 10 YEARS TO QUALIFY)	(1G/4) =	2.43
6.	TOTAL NET DISCOUNTED SAVINGS	(2H5 + 3C) =	$438,211
7.	DISCOUNTED SAVINGS-TO-INVESTMENT RATIO (SIR) (MUST HAVE SIR > 1.25 TO QUALIFY)	(6/1G) =	6.14

LIFE CYCLE COST ANALYSIS SUMMARY
ENERGY CONSERVATION INVESTMENT PROGRAM (ECIP)

LOCATION: Badger Army Ammunition Plant	REGION: 2 (Wisconsin)		PROJECT NO: 1406-004
PROJECT TITLE: Leak Detection Study			FISCAL YEAR: 1995
ANALYSIS DATE: 05/09/95	ECONOMIC LIFE:	20	PREPARED BY: T. Poeling

1. INVESTMENT: **ECO #3A - Isolate 'Caretaker' Area #8 (E-Line NC)**

A.	CONSTRUCTION COST	=	$12,191	
B.	SIOH COST	(6.0% of 1A) =	$731	
C.	DESIGN COST	(6.0% of 1A) =	$731	
D.	TOTAL COST	(1A +1B +1C) =	$13,654	
E.	SALVAGE VALUE OF EXISTING EQUIPMENT =		$0	
F.	PUBLIC UTILITY COMPANY REBATE =			
G.	TOTAL INVESTMENT	(1D -1E -1F) =	------->	$13,654

2. ENERGY SAVINGS (+) OR COST (-):
DATE OF NISTR 85-3273-9 USED FOR DISCOUNT FACTORS: JAN '95

	ENERGY SOURCE	FUEL COST $/KGAL (1)	SAVINGS GAL/YR (2)	ANNUAL $ SAVINGS (3)	DISCOUNT FACTOR (4)	DISCOUNTED SAVINGS (5)	
A.	ELECT. (CURRENT)	$0.05	1,004	$47	15.88	$749	
B.	ELECT. (POTENTIAL)	$0.05	1,748	$82	15.88	$1,305	
C.	DIST	$5.00	0	$0	19.16	$0	
D.	NAT GAS	$4.00	0	$0	18.30	$0	
E.	COAL	$2.60	0	$0	16.62	$0	
G.	DEMAND SAV'GS (KW)	$6.82	0	$0	14.88	$0	
H.	TOTAL		2,752	$129		-------->	$2,054

3. NON-ENERGY SAVINGS (+) OR COST (-)

A. ANNUAL RECURRING (+/-)

1 WELL MAINTENANCE ($0.27/KGAL)	$743	14.88	$11,055
2 WATER DIST. MAINTENANCE ($1.22/KGAL)	$3,357	14.88	$49,954
3 CHEMICAL TREAT. SAVINGS ($0.032/KGAL)	$88	14.88	$1,310
4 TOTAL ANNUAL DISC. SAVINGS (+) / COST (-	$4,188		$62,320

B. NON-RECURRING (+/-)

ITEM	SAVINGS (+) COST(-) (1)	YEAR OF CCURRENCE (2)	DISCOUNT FACTOR (3) (TABLE A-2	DISCOUNTED SAVINGS/ COST (4)
a.				$0
b.				$0
c.				$0
d. TOTAL	$0			$0

C. TOTAL NON-ENERGY DISCOUNTED SAVINGS (+) OR COST (-) (3A4 + 3Bd4) = $62,320

4.	FIRST YEAR DOLLAR SAVINGS (+) / COSTS (-)	(2H3+3A+(3Bd1/Economic Life))	$4,317
5.	SIMPLE PAYBACK (SPB) IN YEARS (MUST BE < 10 YEARS TO QUALIFY)	(1G/4) =	3.16
6.	TOTAL NET DISCOUNTED SAVINGS	(2H5 + 3C) =	$64,374
7.	DISCOUNTED SAVINGS-TO-INVESTMENT RATIO (SIR) (MUST HAVE SIR > 1.25 TO QUALIFY)	(6/1G) =	4.71

LIFE CYCLE COST ANALYSIS SUMMARY
ENERGY CONSERVATION INVESTMENT PROGRAM (ECIP)

LOCATION:	Badger Army Ammunition Plant	REGION: 2 (Wisconsin)		PROJECT NO:	1406-004
PROJECT TITLE:	Leak Detection Study			FISCAL YEAR:	1995
ANALYSIS DATE:	05/09/95	ECONOMIC LIFE:	20	PREPARED BY:	T. Poeling

1. INVESTMENT: **ECO #3B - Isolate 'Caretaker' Area #1 (Old Acid Area)**

A.	CONSTRUCTION COST	=	$7,434	
B.	SIOH COST	(6.0% of 1A) =	$446	
C.	DESIGN COST	(6.0% of 1A) =	$446	
D.	TOTAL COST	(1A +1B +1C) =	$8,326	
E.	SALVAGE VALUE OF EXISTING EQUIPMENT =		$0	
F.	PUBLIC UTILITY COMPANY REBATE =			
G.	TOTAL INVESTMENT	(1D -1E -1F) =	------->	$8,326

2. ENERGY SAVINGS (+) OR COST (-):

DATE OF NISTR 85-3273-9 USED FOR DISCOUNT FACTORS: JAN '95

	ENERGY SOURCE	FUEL COST $/KGAL (1)	SAVINGS GAL/YR (2)	ANNUAL $ SAVINGS (3)	DISCOUNT FACTOR (4)	DISCOUNTED SAVINGS (5)	
A.	ELECT. (CURRENT)	$0.05	274	$13	15.88	$204	
B.	ELECT. (POTENTIAL)	$0.05	727	$34	15.88	$543	
C.	DIST	$5.00	0	$0	19.16	$0	
D.	NAT GAS	$4.00	0	$0	18.30	$0	
E.	COAL	$2.60	0	$0	16.62	$0	
G.	DEMAND SAV'GS (KW)	$6.82	0	$0	14.88	$0	
H.	TOTAL		1,001	$47		-------->	$747

3. NON-ENERGY SAVINGS (+) OR COST (-)

A. ANNUAL RECURRING (+/-)

1 WELL MAINTENANCE ($0.27/KGAL)	$270	14.88	$4,021
2 WATER DIST. MAINTENANCE ($1.22/KGAL)	$1,221	14.88	$18,167
3 CHEMICAL TREAT. SAVINGS ($0.032/KGAL)	$32	14.88	$477
4 TOTAL ANNUAL DISC. SAVINGS (+) / COST (-	$1,523		$22,664

B. NON-RECURRING (+/-)

ITEM	SAVINGS (+) COST(-) (1)	YEAR OF CCURRENCE (2)	DISCOUNT FACTOR (3) (TABLE A-2	DISCOUNTED SAVINGS/ COST (4)
a.				$0
b.				$0
c.				$0
d. TOTAL	$0			$0

C.	TOTAL NON-ENERGY DISCOUNTED SAVINGS (+) OR COST (-)	(3A4 + 3Bd4) =	$22,664
4.	FIRST YEAR DOLLAR SAVINGS (+) / COSTS (-)	(2H3+3A+(3Bd1/Economic Life))	$1,570
5.	SIMPLE PAYBACK (SPB) IN YEARS (MUST BE < 10 YEARS TO QUALIFY)	(1G/4) =	5.30
6.	TOTAL NET DISCOUNTED SAVINGS	(2H5 + 3C) =	$23,411
7.	DISCOUNTED SAVINGS-TO-INVESTMENT RATIO (SIR) (MUST HAVE SIR > 1.25 TO QUALIFY)	(6/1G) =	2.81

LIFE CYCLE COST ANALYSIS SUMMARY
ENERGY CONSERVATION INVESTMENT PROGRAM (ECIP)

LOCATION: Badger Army Ammunition Plant	REGION: 2 (Wisconsin)		PROJECT NO: 1406-004
PROJECT TITLE: Leak Detection Study			FISCAL YEAR: 1995
ANALYSIS DATE: 05/09/95	ECONOMIC LIFE:	20	PREPARED BY: T. Poeling

1. INVESTMENT: **ECO #3C - Isolate 'Caretaker' Area #12 (D-Line SB)**

A.	CONSTRUCTION COST	=	$4,778	
B.	SIOH COST	(6.0% of 1A) =	$287	
C.	DESIGN COST	(6.0% of 1A) =	$287	
D.	TOTAL COST	(1A +1B +1C) =	$5,351	
E.	SALVAGE VALUE OF EXISTING EQUIPMENT =		$0	
F.	PUBLIC UTILITY COMPANY REBATE =			
G.	TOTAL INVESTMENT	(1D -1E -1F) =	------->	$5,351

2. ENERGY SAVINGS (+) OR COST (-):

DATE OF NISTR 85-3273-9 USED FOR DISCOUNT FACTORS: JAN '95

	ENERGY SOURCE	FUEL COST $/KGAL (1)	SAVINGS GAL/YR (2)	ANNUAL $ SAVINGS (3)	DISCOUNT FACTOR (4)	DISCOUNTED SAVINGS (5)	
A.	ELECT. (CURRENT)	$0.05	2,190	$103	15.88	$1,635	
B.	ELECT. (POTENTIAL)	$0.05	937	$44	15.88	$699	
C.	DIST	$5.00	0	$0	19.16	$0	
D.	NAT GAS	$4.00	0	$0	18.30	$0	
E.	COAL	$2.60	0	$0	16.62	$0	
G.	DEMAND SAV'GS (KW)	$6.82	0	$0	14.88	$0	
H.	TOTAL		3,127	$147		-------->	$2,334

3. NON-ENERGY SAVINGS (+) OR COST (-)

A. ANNUAL RECURRING (+/-)

		ANNUAL $	DISCOUNT FACTOR	DISCOUNTED SAVINGS
1	WELL MAINTENANCE ($0.27/KGAL)	$844	14.88	$12,563
2	WATER DIST. MAINTENANCE ($1.22/KGAL)	$3,815	14.88	$56,766
3	CHEMICAL TREAT. SAVINGS ($0.032/KGAL)	$100	14.88	$1,489
4	TOTAL ANNUAL DISC. SAVINGS (+) / COST (-	$4,759		$70,818

B. NON-RECURRING (+/-)

ITEM	SAVINGS (+) COST(-) (1)	YEAR OF CCURRENCE (2)	DISCOUNT FACTOR (3) (TABLE A-2	DISCOUNTED SAVINGS/ COST (4)
a.				$0
b.				$0
c.				$0
d. TOTAL	$0			$0

C. TOTAL NON-ENERGY DISCOUNTED SAVINGS (+) OR COST (-) (3A4 + 3Bd4) = $70,818

4.	FIRST YEAR DOLLAR SAVINGS (+) / COSTS (-)	(2H3+3A+(3Bd1/Economic Life))	$4,906
5.	SIMPLE PAYBACK (SPB) IN YEARS (MUST BE < 10 YEARS TO QUALIFY)	(1G/4) =	1.09
6.	TOTAL NET DISCOUNTED SAVINGS	(2H5 + 3C) =	$73,152
7.	DISCOUNTED SAVINGS-TO-INVESTMENT RATIO (SIR) (MUST HAVE SIR > 1.25 TO QUALIFY)	(6/1G) =	13.67

LIFE CYCLE COST ANALYSIS SUMMARY

ENERGY CONSERVATION INVESTMENT PROGRAM (ECIP)

LOCATION:	Badger Army Ammunition Plant	REGION: 2 (Wisconsin)		PROJECT NO:	1406-004
PROJECT TITLE:	Leak Detection Study			FISCAL YEAR:	1995
ANALYSIS DATE:	05/09/95	ECONOMIC LIFE:	20	PREPARED BY:	T. Poeling

1. INVESTMENT: **ECO #3D - Isolate 'Caretaker' Area #13 (E-Line SB)**

A.	CONSTRUCTION COST	=	$12,211	
B.	SIOH COST	(6.0% of 1A) =	$733	
C.	DESIGN COST	(6.0% of 1A) =	$733	
D.	TOTAL COST	(1A +1B +1C) =	$13,676	
E.	SALVAGE VALUE OF EXISTING EQUIPMENT =		$0	
F.	PUBLIC UTILITY COMPANY REBATE =			
G.	TOTAL INVESTMENT	(1D -1E -1F) =	------->	$13,676

2. ENERGY SAVINGS (+) OR COST (-):

DATE OF NISTR 85-3273-9 USED FOR DISCOUNT FACTORS: JAN '95

	ENERGY SOURCE	FUEL COST $/KGAL (1)	SAVINGS GAL/YR (2)	ANNUAL $ SAVINGS (3)	DISCOUNT FACTOR (4)	DISCOUNTED SAVINGS (5)	
A.	ELECT. (CURRENT)	$0.05	0	$0	15.88	$0	
B.	ELECT. (POTENTIAL)	$0.05	1,203	$57	15.88	$898	
C.	DIST	$5.00	0	$0	19.16	$0	
D.	NAT GAS	$4.00	0	$0	18.30	$0	
E.	COAL	$2.60	0	$0	16.62	$0	
G.	DEMAND SAV'GS (KW)	$6.82	0	$0	14.88	$0	
H.	TOTAL		1,203	$57		-------->	$898

3. NON-ENERGY SAVINGS (+) OR COST (-)

A. ANNUAL RECURRING (+/-)

1 WELL MAINTENANCE ($0.27/KGAL)	$325	14.88	$4,833
2 WATER DIST. MAINTENANCE ($1.22/KGAL)	$1,468	14.88	$21,839
3 CHEMICAL TREAT. SAVINGS ($0.032/KGAL)	$38	14.88	$573
4 TOTAL ANNUAL DISC. SAVINGS (+) / COST (-	$1,831		$27,245

B. NON-RECURRING (+/-)

ITEM	SAVINGS (+) COST(-) (1)	YEAR OF CCURRENCE (2)	DISCOUNT FACTOR (3) (TABLE A-2	DISCOUNTED SAVINGS/ COST (4)
a.				$0
b.				$0
c.				$0
d. TOTAL	$0			$0

C. TOTAL NON-ENERGY DISCOUNTED SAVINGS (+) OR COST (-)	(3A4 + 3Bd4) =		$27,245
4. FIRST YEAR DOLLAR SAVINGS (+) / COSTS (-)	(2H3+3A+(3Bd1/Economic Life))		$1,888
5. SIMPLE PAYBACK (SPB) IN YEARS (MUST BE < 10 YEARS TO QUALIFY)	(1G/4) =		7.25
6. TOTAL NET DISCOUNTED SAVINGS	(2H5 + 3C) =		$28,143
7. DISCOUNTED SAVINGS-TO-INVESTMENT RATIO (SIR) (MUST HAVE SIR > 1.25 TO QUALIFY)	(6/1G) =		2.06

LIFE CYCLE COST ANALYSIS SUMMARY
ENERGY CONSERVATION INVESTMENT PROGRAM (ECIP)

LOCATION: Badger Army Ammunition Plant REGION: 2 (Wisconsin) PROJECT NO: 1406-004
PROJECT TITLE: Leak Detection Study FISCAL YEAR: 1995
ANALYSIS DATE: 05/09/95 ECONOMIC LIFE: 20 PREPARED BY: T. Poeling

1. INVESTMENT: **ECO #3E - Isolate 'Caretaker' Area #9 (F-Line NC)**

A.	CONSTRUCTION COST	=	$12,133	
B.	SIOH COST	(6.0% of 1A) =	$728	
C.	DESIGN COST	(6.0% of 1A) =	$728	
D.	TOTAL COST	(1A +1B +1C) =	$13,589	
E.	SALVAGE VALUE OF EXISTING EQUIPMENT =		$0	
F.	PUBLIC UTILITY COMPANY REBATE =			
G.	TOTAL INVESTMENT	(1D -1E -1F) =	------->	$13,589

2. ENERGY SAVINGS (+) OR COST (-):
DATE OF NISTR 85-3273-9 USED FOR DISCOUNT FACTORS: JAN '95

	ENERGY SOURCE	FUEL COST $/KGAL (1)	SAVINGS GAL/YR (2)	ANNUAL $ SAVINGS (3)	DISCOUNT FACTOR (4)	DISCOUNTED SAVINGS (5)	
A.	ELECT. (CURRENT)	$0.05	0	$0	15.88	$0	
B.	ELECT. (POTENTIAL)	$0.05	1,456	$68	15.88	$1,087	
C.	DIST	$5.00	0	$0	19.16	$0	
D.	NAT GAS	$4.00	0	$0	18.30	$0	
E.	COAL	$2.60	0	$0	16.62	$0	
G.	DEMAND SAV'GS (KW)	$6.82	0	$0	14.88	$0	
H.	TOTAL		1,456	$68		-------->	$1,087

3. NON-ENERGY SAVINGS (+) OR COST (-)

A. ANNUAL RECURRING (+/-)

1 WELL MAINTENANCE ($0.27/KGAL)	$393	14.88	$5,850
2 WATER DIST. MAINTENANCE ($1.22/KGAL)	$1,776	14.88	$26,432
3 CHEMICAL TREAT. SAVINGS ($0.032/KGAL)	$47	14.88	$693
4 TOTAL ANNUAL DISC. SAVINGS (+) / COST (-	$2,216		$32,975

B. NON-RECURRING (+/-)

ITEM	SAVINGS (+) COST(-) (1)	YEAR OF CCURRENCE (2)	DISCOUNT FACTOR (3) (TABLE A-2	DISCOUNTED SAVINGS/ COST (4)
a.				$0
b.				$0
c.				$0
d. TOTAL	$0			$0

C. TOTAL NON-ENERGY DISCOUNTED SAVINGS (+) OR COST (-) (3A4 + 3Bd4) = $32,975

4.	FIRST YEAR DOLLAR SAVINGS (+) / COSTS (-)	(2H3+3A+(3Bd1/Economic Life))	$2,284
5.	SIMPLE PAYBACK (SPB) IN YEARS (MUST BE < 10 YEARS TO QUALIFY)	(1G/4) =	5.95
6.	TOTAL NET DISCOUNTED SAVINGS	(2H5 + 3C) =	$34,061
7.	DISCOUNTED SAVINGS-TO-INVESTMENT RATIO (SIR) (MUST HAVE SIR > 1.25 TO QUALIFY)	(6/1G) =	2.51

LIFE CYCLE COST ANALYSIS SUMMARY

ENERGY CONSERVATION INVESTMENT PROGRAM (ECIP)

LOCATION: Badger Army Ammunition Plant	REGION: 2 (Wisconsin)		PROJECT NO: 1406-004
PROJECT TITLE: Leak Detection Study			FISCAL YEAR: 1995
ANALYSIS DATE: 05/09/95	ECONOMIC LIFE:	20	PREPARED BY: T. Poeling

1. INVESTMENT: **ECO #3F - Isolate 'Caretaker' Area #18 (Rocket East)**

A.	CONSTRUCTION COST	=	$15,006	
B.	SIOH COST	(6.0% of 1A) =	$900	
C.	DESIGN COST	(6.0% of 1A) =	$900	
D.	TOTAL COST	(1A +1B +1C) =	$16,807	
E.	SALVAGE VALUE OF EXISTING EQUIPMENT	=	$0	
F.	PUBLIC UTILITY COMPANY REBATE	=		
G.	TOTAL INVESTMENT	(1D -1E -1F) =	------->	$16,807

2. ENERGY SAVINGS (+) OR COST (-):

DATE OF NISTR 85-3273-9 USED FOR DISCOUNT FACTORS: JAN '95

	ENERGY SOURCE	FUEL COST $/KGAL (1)	SAVINGS GAL/YR (2)	ANNUAL $ SAVINGS (3)	DISCOUNT FACTOR (4)	DISCOUNTED SAVINGS (5)	
A.	ELECT. (CURRENT)	$0.05	1,278	$60	15.88	$953	
B.	ELECT. (POTENTIAL)	$0.05	7,917	$372	15.88	$5,909	
C.	DIST	$5.00	0	$0	19.16	$0	
D.	NAT GAS	$4.00	0	$0	18.30	$0	
E.	COAL	$2.60	0	$0	16.62	$0	
G.	DEMAND SAV'GS (KW)	$6.82	0	$0	14.88	$0	
H.	TOTAL		9,195	$432		-------->	$6,862

3. NON-ENERGY SAVINGS (+) OR COST (-)

A. ANNUAL RECURRING (+/-)

1 WELL MAINTENANCE ($0.27/KGAL)	$2,483	14.88	$36,940
2 WATER DIST. MAINTENANCE ($1.22/KGAL)	$11,217	14.88	$166,913
3 CHEMICAL TREAT. SAVINGS ($0.032/KGAL)	$294	14.88	$4,378
4 TOTAL ANNUAL DISC. SAVINGS (+) / COST (-	$13,994		$208,231

B. NON-RECURRING (+/-)

ITEM	SAVINGS (+) COST(-) (1)	YEAR OF CCURRENCE (2)	DISCOUNT FACTOR (3) (TABLE A-2	DISCOUNTED SAVINGS/ COST (4)
a.				$0
b.				$0
c.				$0
d. TOTAL	$0			$0

C. TOTAL NON-ENERGY DISCOUNTED SAVINGS (+) OR COST (-) (3A4 + 3Bd4) = $208,231

4.	FIRST YEAR DOLLAR SAVINGS (+) / COSTS (-)	(2H3+3A+(3Bd1/Economic Life))	$14,426
5.	SIMPLE PAYBACK (SPB) IN YEARS (MUST BE < 10 YEARS TO QUALIFY)	(1G/4) =	1.17
6.	TOTAL NET DISCOUNTED SAVINGS	(2H5 + 3C) =	$215,094
7.	DISCOUNTED SAVINGS-TO-INVESTMENT RATIO (SIR) (MUST HAVE SIR > 1.25 TO QUALIFY)	(6/1G) =	12.80

ENGINEER'S OPINION OF PROBABLE COST

AREA	ACTIVITY	LOCATION	AMENDMENT NO.
	Leak Detection Study	Badger Army Ammunition Plant	

PROJECT TITLE	CONTRACT NO.
ECO #3A - FIX LEAKS IN SPECIFIC CARETAKER AREAS (AREA #8)	DACA01-94-D-0033

Line No.	Item Description	Unit of Measure	Qty.	MATERIAL COST Unit Cost	MATERIAL COST Total	LABOR COST Unit Cost	LABOR COST Total	EQUIPMENT COST Unit Cost	EQUIPMENT COST Total	TOTAL COST Unit Cost	TOTAL COST Total
1	**ISOLATE E-LINE NC**										
2	EXCAVATION	CY	28	$0.00	$0	$1.48	$41	$1.51	$42	$2.99	$84
3	DEWATERING	DAY	3	$0.00	$0	$67.50	$203	$7.80	$23	$75.30	$226
4	VALVE DEMOLITION, TO 16"	EA	2	$0.00	$0	$50.00	$100	$0.00	$0	$50.00	$100
5	VALVE DEMOLITION, TO 24"	EA	3	$0.00	$0	$50.00	$150	$0.00	$0	$50.00	$150
6	BLIND FLANGE, 16"	EA	3	$865.00	$2,595	$315.00	$945	$0.00	$0	$1,180.00	$3,540
7	BLIND FLANGE, 24"	EA	2	$2,425.00	$4,850	$635.00	$1,270	$0.00	$0	$3,060.00	$6,120
8	BACKFILL	CY	28	$0.00	$0	$0.68	$19	$0.56	$16	$1.24	$35
9	COMPACTION	CY	28	$0.00	$0	$0.82	$23	$0.32	$9	$1.14	$32
10				$0	$0	$0	$0	$0	$0	$0.00	$0
11				$0	$0	$0	$0	$0	$0	$0.00	$0
12				$0	$0	$0	$0	$0	$0	$0.00	$0
13											
14											
15											
16											
17	**CONSTRUCTION SUBTOTAL**				$7,445		$2,751		$90		$10,286
18	LOCATION FACTOR			**74.20%**	$5,524	**101.10%**	$2,781	**100.00%**	$90		$8,396
19	OVERHEAD & BOND	%	20		$1,105		$556		$18		$1,679
20	SUBTOTAL				$6,629		$3,337		$108		$10,075
21	PROFIT	%	10		$663		$334		$11		$1,007
22	SUBTOTAL				$7,292		$3,671		$119		$11,082
23	CONTINGENCY	%	10		$729		$367		$12		$1,108
24	**GRAND TOTAL**				$8,021		$4,038		$131		$12,191

PREPARED BY	APPROVED BY	TITLE OR ORGANIZATION	DATE
TCP		E M C Engineers, Inc.	1/20/95

ENGINEER'S OPINION OF PROBABLE COST

SHEET 2 OF 7

AREA	ACTIVITY	LOCATION	AMENDMENT NO.
	Leak Detection Study	Badger Army Ammunition Plant	

PROJECT TITLE	CONTRACT NO.
ECO #3B - FIX LEAKS IN SPECIFIC CARETAKER AREAS (AREA #1)	DACA01-94-D-0033

Line No.	Item Description	Unit of Measure	Qty.	MATERIAL COST Unit Cost	MATERIAL COST Total	LABOR COST Unit Cost	LABOR COST Total	EQUIPMENT COST Unit Cost	EQUIPMENT COST Total	TOTAL COST Unit Cost	TOTAL COST Total
1	**ISOLATE OLD ACID AREA**										
2	EXCAVATION	CY	11	$0.00	$0	$1.48	$16	$1.51	$17	$2.99	$33
3	DEWATERING	DAY	1	$0.00	$0	$67.50	$68	$7.80	$8	$75.30	$75
4	VALVE DEMOLITION, TO 24"	EA	2	$0.00	$0	$50.00	$100	$0.00	$0	$50.00	$100
5	BLIND FLANGE, 24"	EA	2	$2,425.00	$4,850	$635.00	$1,270	$0.00	$0	$3,060.00	$6,120
6	BACKFILL	EA	11	$0.00	$0	$0.68	$8	$0.56	$6	$1.24	$14
7	COMPACTION	EA	11	$0.00	$0	$0.82	$9	$0.32	$4	$1.14	$13
8				$0	$0	$0	$0	$0	$0	$0.00	$0
9				$0	$0	$0	$0	$0	$0	$0.00	$0
10				$0	$0	$0	$0	$0	$0	$0.00	$0
11				$0	$0	$0	$0	$0	$0	$0.00	$0
12				$0	$0	$0	$0	$0	$0	$0.00	$0
13											
14											
15											
16											
17	**CONSTRUCTION SUBTOTAL**				$4,850		$1,471		$34		$6,355
18	LOCATION FACTOR			**74.20%**	$3,599	**101.10%**	$1,487	**100.00%**	$34		$5,120
19	OVERHEAD & BOND	%	20		$720		$297		$7		$1,024
20	SUBTOTAL				$4,318		$1,784		$41		$6,144
21	PROFIT	%	10		$432		$178		$4		$614
22	SUBTOTAL				$4,750		$1,963		$45		$6,758
23	CONTINGENCY	%	10		$475		$196		$5		$676
24	**GRAND TOTAL**				$5,225		$2,159		$50		$7,434

PREPARED BY	APPROVED BY	TITLE OR ORGANIZATION	DATE
TCP		E M C Engineers, Inc.	1/20/95

ENGINEER'S OPINION OF PROBABLE COST

SHEET 3 **OF** 7			
AREA	**ACTIVITY** Leak Detection Study	**LOCATION** Badger Army Ammunition Plant	**AMENDMENT NO.**
PROJECT TITLE ECO #3C - FIX LEAKS IN SPECIFIC CARETAKER AREAS (AREA #12)			**CONTRACT NO.** DACA01-94-D-0033

Line No.	Item Description	Unit of Measure	Qty.	MATERIAL COST Unit Cost	MATERIAL COST Total	LABOR COST Unit Cost	LABOR COST Total	EQUIPMENT COST Unit Cost	EQUIPMENT COST Total	TOTAL COST Unit Cost	TOTAL COST Total
1	**ISOLATE D-LINE SB AREA**										
2	EXCAVATION	CY	22	$0.00	$0	$1.48	$33	$1.51	$34	$2.99	$66
3	DEWATERING	DAY	2	$0.00	$0	$67.50	$135	$7.80	$16	$75.30	$151
4	VALVE DEMOLITION, TO 16"	EA	4	$0.00	$0	$50.00	$200	$0.00	$0	$50.00	$200
5	BLIND FLANGE, 10"	EA	2	$350.00	$700	$186.00	$372	$0.00	$0	$536.00	$1,072
6	BLIND FLANGE, 16"	EA	2	$865.00	$1,730	$315.00	$630	$0.00	$0	$1,180.00	$2,360
7	BACKFILL	EA	22	$0.00	$0	$0.68	$15	$0.56	$12	$1.24	$28
8	COMPACTION	EA	22	$0.00	$0	$0.82	$18	$0.32	$7	$1.14	$25
9				$0	$0	$0	$0	$0	$0	$0.00	$0
10				$0	$0	$0	$0	$0	$0	$0.00	$0
11				$0	$0	$0	$0	$0	$0	$0.00	$0
12				$0	$0	$0	$0	$0	$0	$0.00	$0
13											
14											
15											
16											
17	**CONSTRUCTION SUBTOTAL**				$2,430		$1,403		$69		$3,902
18	LOCATION FACTOR			**74.20%**	$1,803	**101.10%**	$1,419	**100.00%**	$69		$3,290
19	OVERHEAD & BOND	%	20		$361		$284		$14		$658
20	SUBTOTAL				$2,164		$1,702		$82		$3,948
21	PROFIT	%	10		$216		$170		$8		$395
22	SUBTOTAL				$2,380		$1,873		$91		$4,343
23	CONTINGENCY	%	10		$238		$187		$9		$434
24	**GRAND TOTAL**				$2,618		$2,060		$100		$4,778

PREPARED BY	APPROVED BY	TITLE OR ORGANIZATION	DATE
TCP		E M C Engineers, Inc.	1/20/95

ENGINEER'S OPINION OF PROBABLE COST

AREA	ACTIVITY	LOCATION	AMENDMENT NO.
	Leak Detection Study	Badger Army Ammunition Plant	

PROJECT TITLE	CONTRACT NO.
ECO #3D - FIX LEAKS IN SPECIFIC CARETAKER AREAS (AREA #13)	DACA01-94-D-0033

Line No.	Item Description	Unit of Measure	Qty.	MATERIAL COST Unit Cost	MATERIAL COST Total	LABOR COST Unit Cost	LABOR COST Total	EQUIPMENT COST Unit Cost	EQUIPMENT COST Total	TOTAL COST Unit Cost	TOTAL COST Total
1	**ISOLATE E-LINE SB AREA**										
2	EXCAVATION	CY	33	$0.00	$0	$1.48	$49	$1.51	$50	$2.99	$100
3	DEWATERING	DAY	3	$0.00	$0	$67.50	$203	$7.80	$23	$75.30	$226
4	VALVE DEMOLITION, TO 16"	EA	4	$0.00	$0	$50.00	$200	$0.00	$0	$50.00	$200
5	VALVE DEMOLITION, TO 24"	EA	2	$0.00	$0	$50.00	$100	$0.00	$0	$50.00	$100
6	BLIND FLANGE, 10"	EA	2	$350.00	$700	$186.00	$372	$0.00	$0	$536.00	$1,072
7	BLIND FLANGE, 16"	EA	2	$865.00	$1,730	$315.00	$630	$0.00	$0	$1,180.00	$2,360
8	BLIND FLANGE, 24"	EA	2	$2,425.00	$4,850	$635.00	$1,270	$0.00	$0	$3,060.00	$6,120
9	BACKFILL	EA	33	$0.00	$0	$0.68	$23	$0.56	$19	$1.24	$41
10	COMPACTION	EA	33	$0.00	$0	$0.82	$27	$0.32	$11	$1.14	$38
11				$0	$0	$0	$0	$0	$0	$0.00	$0
12				$0	$0	$0	$0	$0	$0	$0.00	$0
13											
14											
15											
16											
17	**CONSTRUCTION SUBTOTAL**				$7,280		$2,874		$103		$10,257
18	LOCATION FACTOR			**74.20%**	$5,402	**101.10%**	$2,905	**100.00%**	$103		$8,410
19	OVERHEAD & BOND	%	20		$1,080		$581		$21		$1,682
20	SUBTOTAL				$6,482		$3,486		$124		$10,092
21	PROFIT	%	10		$648		$349		$12		$1,009
22	SUBTOTAL				$7,130		$3,835		$136		$11,101
23	CONTINGENCY	%	10		$713		$384		$14		$1,110
24	**GRAND TOTAL**				$7,843		$4,219		$150		$12,211

PREPARED BY	APPROVED BY	TITLE OR ORGANIZATION	DATE
TCP		E M C Engineers, Inc.	1/20/95

ENGINEER'S OPINION OF PROBABLE COST

SHEET 5 OF 7

AREA	ACTIVITY	LOCATION	AMENDMENT NO.
	Leak Detection Study	Badger Army Ammunition Plant	

PROJECT TITLE	CONTRACT NO.
ECO #3E - FIX LEAKS IN SPECIFIC CARETAKER AREAS (AREA #09)	DACA01-94-D-0033

Line No.	Item Description	Unit of Measure	Qty.	MATERIAL COST Unit Cost	MATERIAL COST Total	LABOR COST Unit Cost	LABOR COST Total	EQUIPMENT COST Unit Cost	EQUIPMENT COST Total	TOTAL COST Unit Cost	TOTAL COST Total
1	**ISOLATE F-LINE NC AREA**										
2	EXCAVATION	CY	28	$0.00	$0	$1.48	$41	$1.51	$42	$2.99	$83
3	DEWATERING	DAY	3	$0.00	$0	$67.50	$169	$7.80	$20	$75.30	$188
4	VALVE DEMOLITION, TO 16"	EA	3	$0.00	$0	$50.00	$150	$0.00	$0	$50.00	$150
5	VALVE DEMOLITION, TO 24"	EA	2	$0.00	$0	$50.00	$100	$0.00	$0	$50.00	$100
6	BLIND FLANGE, 16"	EA	3	$865.00	$2,595	$315.00	$945	$0.00	$0	$1,180.00	$3,540
7	BLIND FLANGE, 24"	EA	2	$2,425.00	$4,850	$635.00	$1,270	$0.00	$0	$3,060.00	$6,120
8	BACKFILL	EA	28	$0.00	$0	$0.68	$19	$0.56	$16	$1.24	$34
9	COMPACTION	EA	28	$0.00	$0	$0.82	$23	$0.32	$9	$1.14	$32
10				$0	$0	$0	$0	$0	$0	$0.00	$0
11				$0	$0	$0	$0	$0	$0	$0.00	$0
12				$0	$0	$0	$0	$0	$0	$0.00	$0
13											
14											
15											
16											
17	**CONSTRUCTION SUBTOTAL**				$7,445		$2,716		$86		$10,247
18	LOCATION FACTOR			**74.20%**	$5,524	**101.10%**	$2,746	**100.00%**	$86		$8,356
19	OVERHEAD & BOND	%	20		$1,105		$549		$17		$1,671
20	SUBTOTAL				$6,629		$3,296		$103		$10,028
21	PROFIT	%	10		$663		$330		$10		$1,003
22	SUBTOTAL				$7,292		$3,625		$113		$11,030
23	CONTINGENCY	%	10		$729		$363		$11		$1,103
24	**GRAND TOTAL**				$8,021		$3,988		$125		$12,133

PREPARED BY	APPROVED BY	TITLE OR ORGANIZATION	DATE
TCP		E M C Engineers, Inc.	1/20/95

ENGINEER'S OPINION OF PROBABLE COST

AREA	ACTIVITY	LOCATION	AMENDMENT NO.
	Leak Detection Study	Badger Army Ammunition Plant	

PROJECT TITLE	CONTRACT NO.
ECO #3F - FIX LEAKS IN SPECIFIC CARETAKER AREAS (AREA #18)	DACA01-94-D-0033

Line No.	Item Description	Unit of Measure	Qty.	MATERIAL COST Unit Cost	MATERIAL COST Total	LABOR COST Unit Cost	LABOR COST Total	EQUIPMENT COST Unit Cost	EQUIPMENT COST Total	TOTAL COST Unit Cost	TOTAL COST Total
1	**ISOLATE ROCKET EAST**										
2	EXCAVATION	CY	61	$0.00	$0	$1.48	$90	$1.51	$92	$2.99	$182
3	DEWATERING	DAY	6	$0.00	$0	$67.50	$371	$7.80	$43	$75.30	$414
4	VALVE DEMOLITION, TO 16"	EA	11	$0.00	$0	$50.00	$550	$0.00	$0	$50.00	$550
5	BLIND FLANGE, 12"	EA	4	$470.00	$1,880	$226.00	$904	$0.00	$0	$696.00	$2,784
6	BLIND FLANGE, 16"	EA	7	$865.00	$6,055	$315.00	$2,205	$0.00	$0	$1,180.00	$8,260
7	BACKFILL	EA	61	$0.00	$0	$0.68	$41	$0.56	$34	$1.24	$76
8	COMPACTION	EA	61	$0.00	$0	$0.82	$50	$0.32	$20	$1.14	$70
9				$0	$0	$0	$0	$0	$0	$0.00	$0
10				$0	$0	$0	$0	$0	$0	$0.00	$0
11				$0	$0	$0	$0	$0	$0	$0.00	$0
12				$0	$0	$0	$0	$0	$0	$0.00	$0
13											
14											
15											
16											
17	**CONSTRUCTION SUBTOTAL**				$7,935		$4,212		$189		$12,336
18	LOCATION FACTOR			**74.20%**	$5,888	**101.10%**	$4,258	**100.00%**	$189		$10,335
19	OVERHEAD & BOND	%	20		$1,178		$852		$38		$2,067
20	SUBTOTAL				$7,065		$5,110		$226		$12,402
21	PROFIT	%	10		$707		$511		$23		$1,240
22	SUBTOTAL				$7,772		$5,621		$249		$13,642
23	CONTINGENCY	%	10		$777		$562		$25		$1,364
24	**GRAND TOTAL**				**$8,549**		**$6,183**		**$274**		**$15,006**

PREPARED BY	APPROVED BY	TITLE OR ORGANIZATION	DATE
TCP		E M C Engineers, Inc.	1/20/95

ENGINEER'S OPINION OF PROBABLE COST

AREA

ACTIVITY Leak Detection Study

LOCATION Badger Army Ammunition Plant

AMENDMENT NO.

PROJECT TITLE ECO #3 - ISOLATE ALL CARETAKER AREAS

CONTRACT NO. DACA01-94-D-0033

Line No.	Item Description	Unit of Measure	Qty.	MATERIAL COST Unit Cost	MATERIAL COST Total	LABOR COST Unit Cost	LABOR COST Total	EQUIPMENT COST Unit Cost	EQUIPMENT COST Total	TOTAL COST Unit Cost	TOTAL COST Total
1	**SUMMARY**										
2	ECO #3A - ISOLATE AREA #8	EA	1		$7,445		$2,751		$90		$10,286
3	ECO #3B - ISOLATE AREA #1	EA	1		$4,850		$1,471		$34		$6,355
4	ECO #3C - ISOLATE AREA #12	EA	1		$2,430		$1,403		$69		$3,902
5	ECO #3D - ISOLATE AREA #13	EA	1		$7,280		$2,874		$103		$10,257
6	ECO #3E - ISOLATE AREA #9	EA	1		$7,445		$2,716		$86		$10,247
7	ECO #3F - ISOLATE AREA #18	EA	1		$7,935		$4,212		$189		$12,336
8											
9											
10											
11											
12											
13											
14											
15											
16											
17	**CONSTRUCTION SUBTOTAL**				$37,385		$15,427		$571		$53,383
18	LOCATION FACTOR	%		**74.20%**	$27,740	**101.10%**	$15,597	**100.00%**	$571		$43,907
19	OVERHEAD & BOND	%	20		$5,548		$3,119		$114		$8,781
20	SUBTOTAL				$33,288		$18,716		$685		$52,688
21	PROFIT	%	10		$3,329		$1,872		$68		$5,269
22	SUBTOTAL				$36,616		$20,587		$753		$57,957
23	CONTINGENCY	%	10		$3,662		$2,059		$75		$5,796
24	**GRAND TOTAL**				**$40,278**		**$22,646**		**$829**		**$63,753**

PREPARED BY	APPROVED BY	TITLE OR ORGANIZATION	DATE
TCP		E M C Engineers, Inc.	1/20/95

LIFE CYCLE COST ANALYSIS SUMMARY
ENERGY CONSERVATION INVESTMENT PROGRAM (ECIP)

LOCATION	Badger Army Ammunition Plant	REGION: 2 (Wisconsin)	PROJECT NO: 1406-004
PROJECT TITLE:	Leak Detection Study		FISCAL YEAR: 1995
ANALYSIS DATE:	05/09/95	ECONOMIC LIFE: 20	PREPARED BY: T. Poeling

1. INVESTMENT: **ECO #4 - Implement Leak Detection Program After ECO #2 and #3**

A.	CONSTRUCTION COST	=	$15,750	
B.	SIOH COST	(6.0% of 1A) =	$945	
C.	DESIGN COST	(6.0% of 1A) =	$945	
D.	TOTAL COST	(1A +1B +1C) =	$17,640	
E.	SALVAGE VALUE OF EXISTING EQUIPMENT =		$0	
F.	PUBLIC UTILITY COMPANY REBATE =			
G.	TOTAL INVESTMENT	(1D -1E -1F) =	------->	$17,640

2. ENERGY SAVINGS (+) OR COST (-):

DATE OF NISTR 85-3273-9 USED FOR DISCOUNT FACTORS: JAN '95

	ENERGY SOURCE	FUEL COST $/KGAL (1)	SAVINGS KGAL/YR (2)	ANNUAL $ SAVINGS (3)	DISCOUNT FACTOR (4)	DISCOUNTED SAVINGS (5)	
A.	ELECT. (CURRENT)	$0.05	61,708	$2,900	15.88	$46,056	
B.	ELECT. (POTENTIAL)	$0.05	0	$0	15.88	$0	
C.	DIST	$5.00	0	$0	19.16	$0	
D.	NAT GAS	$4.00	0	$0	18.30	$0	
E.	COAL	$2.60	0	$0	16.62	$0	
G.	DEMAND SAV'GS (KW	$6.82	0	$0	14.88	$0	
H.	TOTAL		61,708	$2,900		-------->	$46,056

3. NON-ENERGY SAVINGS (+) OR COST (-)

A. ANNUAL RECURRING (+/-)

1 WELL MAINTENANCE ($0.27/KGAL)	$16,661	14.88	$247,917
2 WATER DIST. MAINTENANCE ($1.22/KGAL)	$0	14.88	$0
3 CHEMICAL TREAT. SAVINGS ($0.032/KGAL)	$1,975	14.88	$29,383
4 TOTAL ANNUAL DISC. SAVINGS (+) / COST (-)	$18,636		$277,300

B. NON-RECURRING (+/-)

ITEM	SAVINGS (+) COST(-) (1)	YEAR OF CCURRENCE (2)	DISCOUNT FACTOR (3) (TABLE A-2)	DISCOUNTED SAVINGS/ COST (4)
a.				$0
b.				$0
c.				$0
d. TOTAL	$0			$0

C. TOTAL NON-ENERGY DISCOUNTED SAVINGS (+) OR COST (-) (3A4 + 3Bd4) = $277,300

4.	FIRST YEAR DOLLAR SAVINGS (+) / COSTS (-)	(2H3+3A+(3Bd1/Economic Life))	$21,536
5.	SIMPLE PAYBACK (SPB) IN YEARS (MUST BE < 10 YEARS TO QUALIFY)	(1G/4) =	0.82
6.	TOTAL NET DISCOUNTED SAVINGS	(2H5 + 3C) =	$323,356
7.	DISCOUNTED SAVINGS-TO-INVESTMENT RATIO (SIR) (MUST HAVE SIR > 1.25 TO QUALIFY)	(6/1G) =	18.33

WATER AUDIT WORKSHEET

			Gallons/Year
Total Amount of Water Pumped (metered):			250,900,000
Leakage Saved by Relining Pipes (ECO #2)			54,636,000
Leakage Saved by Isolating "Caretaker" Areas (ECO #3)			18,732,000
Net Water Pumped after ECO Implementation:			**177,532,000**
Unmetered Water Uses (Provided by BAAP):			
Fire hydrant exercising:	2000 gpm x 10 min x 675 hydrants	=	13,500,000
Industrial uses:			
Boilers	32,000,000 lbs/yr x 1,198 gals/lb	=	3,900,000
Cooling Water	40 gpm x 1,440 min/day x 365 days/yr	=	21,100,000
Domestic Water	525,000 gals/month x 12 months/yr	=	6,300,000
Maintenance Activities	20 gpm x 60 min/hr x 10 hrs/day x 4 days/wk x 52 wk/yr	=	2,500,000
Irrigation (Cattle)	400,000 gals/month x 6 months	=	2,400,000
Discovered Leaks (by maintenance personnel, not leak detection survey):			
Main water breaks	50 breaks x 20 gpm x 1,440 min/day x 30 days	=	43,200,000
Service laterals & valves	13 breaks x 2 gpm x 1,440 min/day x 30 days	=	1,123,200
Reservoir Evaporation (calculated value)		=	1,231,700
Total Identified Water Losses:			**95,254,900**
Potential Water System Leakage:			**82,277,100**
Recoverable Leakage (AWWA Manual 36 estimates 75% is recoverable):			**61,707,825**
Cost of Water Supply (per 1000 gallons):	($0.047 pumping costs, $0.032 chemical treatment, $0.27 well maintenance)		**$0.349**
One Year Benefit from Recoverable Leakage:			**$21,536**
Total Cost of Leak Detection Program:	($150 / mile x 105 miles + 6% SIOH + 6% Design)	=	**$17,640**
Benefit-to-Cost Ratio (One Year Audit):			**1.22**
Simple Payback (years):			**0.82**

 (Taken From AWWA Manual 36)

WATER AUDIT WORKSHEET

For: Badger Army Ammunition Plant Audit Study Period: Avg. Year

Line	Item	Subtotal	Total Cumulative	Units*
			Water Volume	
Task 1—Measure Supply				
1	Uncorrected total water supply to the distribution system (total of master meters)		177,532,000	gal/yr.
2A-C	Adjustments to total water supply			
2A	Source meter error (+ or –)	–		
2B	Change in reservoir and tank storage (+ or –)	–		
2C	Other contributions or losses (+ or –)	–		
3	Total adjustments to total water supply (add lines 2A, 2B, and 2C)	–		
4	Adjusted total water supply to the distribution system (add line 1 and line 3)		177,532,000	gal/yr.
Task 2—Measure Metered Use				
5	Uncorrected total metered water use	–		
6	Adjustments due to meter reading lag time (+ or –)	–		
7	Metered deliveries (add lines 5 and 6)	–		
8A-C	Total sales meter error and system-service meter errors (+ or –)			
8A	Residential meter error	–		
8B	Large meter error	–		
8C	Total (add line 8A and 8B)	–		
9	Corrected total metered water deliveries (add lines 7 and 8C)	–		
10	Corrected total unmetered water (subtract line 9 from line 4)		177,532,000	gal/yr.
11A-M	Authorized unmetered water uses			
11A	Firefighting and firefighting training	13,500,000		gal/yr.
11B	Main flushing			

NOTE: 1 ac-ft = 43,560 ft^3 = 325,851 gal.

*Units of measure must be consistent throughout the worksheet. The particular unit used (that is, acre-feet, millions of gallons, cubic feet, cubic metres, or other unit) is left to the user.

Form continues on next page.

Line	Item	Water Volume Subtotal	Water Volume Total Cumulative	Units*
11A-M	Authorized unmetered water uses (continued)			
11C	Storm drain flushing	–		
11D	Sewer cleaning	–		
11E	Street cleaning	–		
11F	Schools	–		
11G	Landscaping in large public areas:			
	Parks	–		
	Golf courses	–		
	Cemeteries	–		
	Playgrounds	–		
	Highway median strips	–		
	Other landscaping	–		
11H	Decorative water facilities	–		
11I	Swimming pools	–		
11J	Construction sites			
11K	Water quality and other testing (pressure testing pipe, water quality, etc.)	–		
11L	Process water at ~~treatment plants~~ industrial uses	33,800,000		gal/yr.
11M	Other unmetered uses (irrigation)	2,400,000		gal/yr.
12	Total authorized unmetered water (add lines 11A through 11M)		49,700,000	gal/yr.
13	Total water losses (subtract line 12 from line 10)		127,832,000	gal/yr.
14A-H	Identified water losses			
14A	Accounting procedure errors	–		
14B	Illegal connections	–		
14C	Malfunctioning distribution system controls	–		
14D	Reservoir seepage and leakage	–		
14E	Evaporation	1,231,700		gal/yr.

NOTE: 1 ac-ft = 43,560 ft^3 = 325,851 gal.

*Units of measure must be consistent throughout the worksheet. The particular unit used (that is, acre-feet, millions of gallons, cubic feet, cubic metres, or other unit) is left to the user.

Form continues on next page.

Line	Item	Water Volume: Subtotal	Water Volume: Total Cumulative	Units*
14A-H	Identified water losses (continued)			
14F	Reservoir overflow	-		
14G	Discovered leaks	44,323,200		gal/yr.
14H	Theft			
15	Total identified water losses (add lines 14A through 14H)	45,554,900		gal/yr.
16	Potential water system leakage (subtract line 15 from line 13)		82,277,100	gal/yr.
17	Recoverable leakage (multiply line 16 by 0.75)		61,707,825	gal/yr.

Line	Item	Dollars per Unit of Volume
18A-B	Cost savings	
18A	Cost of water supply	$0.047/1000 gal (Pumping cost)
18B	Variable operation and maintenance costs	$0.302/1000 gal (Chemical, well cost)
19	Total costs per unit of recoverable leakage (add line 18A and line 18B)	$0.349/1000 gal

Line	Item	Dollars per Year
20	One-year benefit from recoverable leakage (multiply line 17 by line 19)	$21,536
21	Total benefits from recovered leakage (multiply line 20 by 2)	$43,072
22	Total costs of leak detection project	$17,640
23	Benefit to cost ratio (divide line 21 by line 22)	2.44

Prepared by:

Name Tom Roeling

Title EMC Engineers, Inc. Date 4/20/95

NOTE: 1 ac-ft = 43,560 ft^3 = 325,851 gal.

*Units of measure must be consistent throughout the worksheet. The particular unit used (that is, acre-feet, millions of gallons, cubic feet, cubic metres, or other unit) is left to the user.

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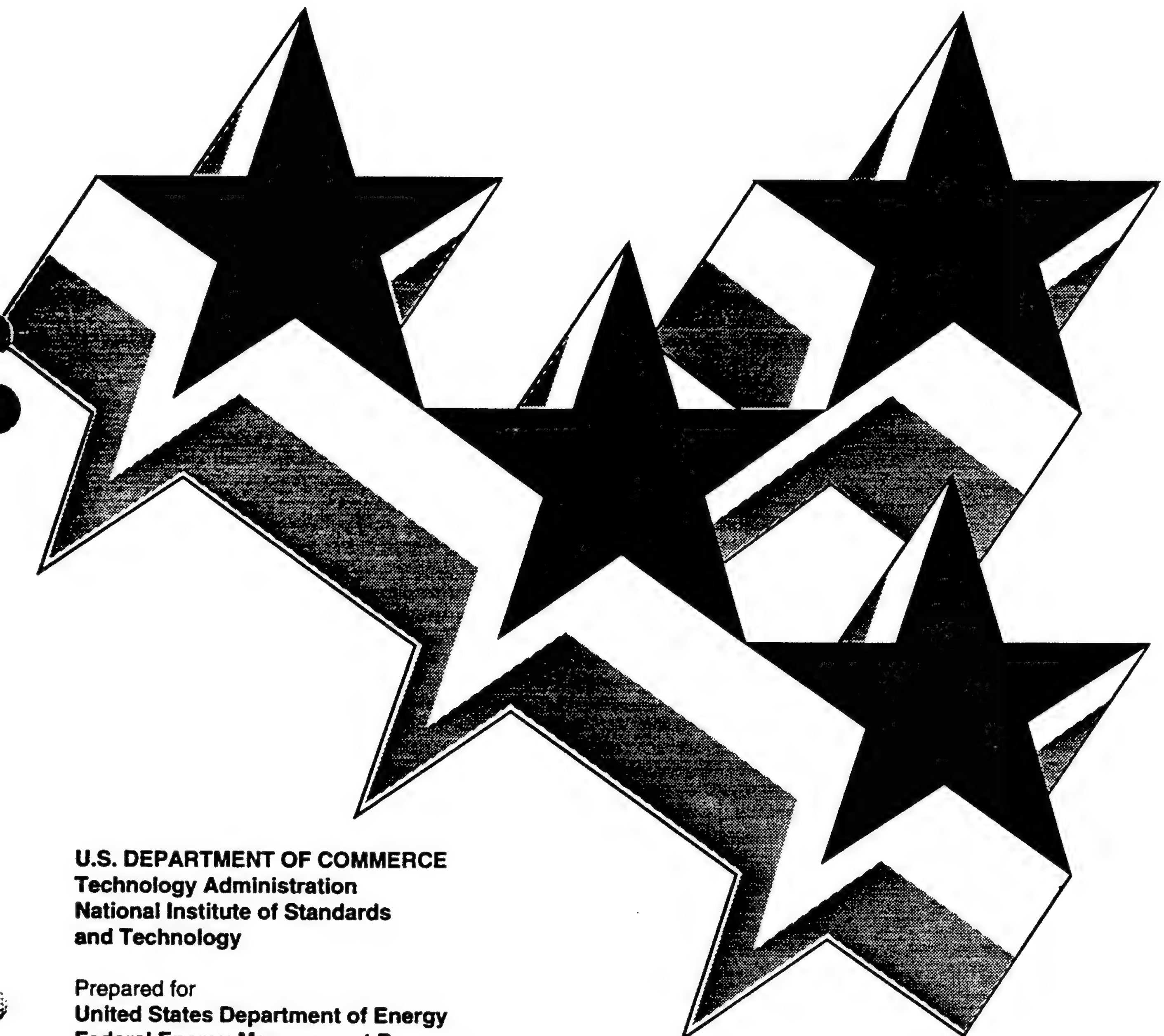
Energy Price Indices and Discount Factors for Life-Cycle Cost Analysis 1995

Annual Supplement to
NIST Handbook 135 and
NBS Special Publication 709

Stephen R. Petersen



U.S. DEPARTMENT OF COMMERCE
Technology Administration
National Institute of Standards and Technology

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Table Ba-2. UPV* Discount Factors adjusted for fuel price escalation, by end-use sector and fuel type.[a] Discount Rate = 3.0 percent (FEMP)

Census Region 2 (Illinois, Indiana, Iowa, Kansas, Michigan, Minnesota, Missouri, Nebraska, North Dakota, Ohio, South Dakota, Wisconsin)

	RESIDENTIAL				COMMERCIAL					INDUSTRIAL					TRANSPORT	
N	ELEC	DIST	LPG	NTGAS	ELEC	DIST	RESID	NTGAS	COAL	ELEC	DIST	RESID	NTGAS	COAL	GASLN	N
1	0.98	0.99	0.98	1.00	0.98	0.99	1.02	1.00	1.00	0.98	0.99	1.02	1.00	0.97	1.00	1
2	1.94	1.97	1.95	1.99	1.93	1.99	2.05	2.00	1.97	1.93	1.98	2.05	1.99	1.93	2.00	2
3	2.87	2.94	2.91	2.96	2.86	2.98	3.08	2.98	2.92	2.85	2.97	3.08	2.97	2.87	2.99	3
4	3.78	3.90	3.87	3.92	3.78	3.98	4.12	3.94	3.84	3.76	3.96	4.13	3.95	3.79	3.96	4
5	4.68	4.85	4.82	4.85	4.67	4.98	5.17	4.88	4.75	4.65	4.94	5.18	4.90	4.70	4.92	5
6	5.56	5.80	5.77	5.76	5.54	5.98	6.24	5.80	5.63	5.51	5.93	6.25	5.84	5.60	5.88	6
7	6.42	6.75	6.72	6.65	6.40	6.98	7.32	6.70	6.52	6.36	6.92	7.34	6.77	6.47	6.83	7
8	7.27	7.69	7.67	7.52	7.24	7.99	8.42	7.59	7.38	7.19	7.91	8.43	7.70	7.31	7.76	8
9	8.10	8.63	8.61	8.39	8.05	9.01	9.52	8.47	8.22	8.00	8.90	9.55	8.61	8.13	8.68	9
10	8.90	9.55	9.54	9.24	8.85	10.01	10.64	9.34	9.04	8.78	9.88	10.66	9.53	8.95	9.59	10
11	9.70	10.47	10.45	10.09	9.63	11.01	11.74	10.20	9.82	9.55	10.85	11.77	10.44	9.75	10.48	11
12	10.48	11.37	11.36	10.94	10.39	12.00	12.84	11.06	10.57	10.30	11.82	12.88	11.34	10.54	11.36	12
13	11.26	12.26	12.26	11.77	11.14	12.98	13.94	11.92	11.31	11.03	12.77	13.98	12.24	11.31	12.22	13
14	12.03	13.14	13.15	12.60	11.88	13.96	15.02	12.77	12.02	11.75	13.72	15.07	13.14	12.10	13.07	14
15	12.80	14.00	14.02	13.41	12.60	14.92	16.09	13.60	12.71	12.47	14.66	16.14	14.02	12.89	13.90	15
16	13.54	14.85	14.88	14.21	13.30	15.87	17.14	14.43	13.37	13.19	15.58	17.20	14.89	13.66	14.72	16
17	14.27	15.69	15.73	15.00	13.98	16.81	18.19	15.24	14.02	13.89	16.49	18.26	15.75	14.43	15.52	17
18	14.98	16.51	16.56	15.77	14.64	17.74	19.24	16.04	14.66	14.57	17.39	19.32	16.61	15.17	16.31	18
19	15.68	17.31	17.39	16.54	15.28	18.65	20.28	16.83	15.28	15.23	18.28	20.38	17.46	15.90	17.09	19
20	16.36	18.11	18.20	17.29	15.90	19.55	21.31	17.60	15.88	15.88	19.16	21.43	18.30	16.62	17.86	20
21	17.03	18.88	18.99	18.03	16.51	20.44	22.34	18.37	16.47	16.51	20.02	22.48	19.13	17.32	18.62	21
22	17.69	19.65	19.78	18.75	17.10	21.32	23.37	19.12	17.05	17.13	20.88	23.52	19.95	18.02	19.37	22
23	18.33	20.40	20.55	19.47	17.67	22.19	24.39	19.87	17.62	17.73	21.72	24.57	20.77	18.69	20.11	23
24	18.96	21.14	21.31	20.17	18.22	23.04	25.40	20.60	18.17	18.32	22.55	25.61	21.58	19.36	20.84	24
25	19.58	21.86	22.06	20.86	18.76	23.88	26.41	21.33	18.71	18.89	23.38	26.65	22.38	20.01	21.56	25
26/a	20.19	22.58	22.80	21.54	19.28	24.72	27.41	22.04	19.24	19.44	24.19	27.68	23.17	20.65	22.27	26
27/a	20.78	23.28	23.53	22.21	19.79	25.54	28.41	22.75	19.76	19.99	24.99	28.71	23.96	21.27	22.97	27
28/a	21.36	23.96	24.25	22.87	20.29	26.35	29.41	23.44	20.26	20.51	25.78	29.74	24.74	21.89	23.65	28
29/a	21.93	24.64	24.95	23.52	20.77	27.14	30.39	24.13	20.75	21.03	26.57	30.77	25.51	22.49	24.33	29
30/a	22.49	25.30	25.64	24.16	21.23	27.93	31.38	24.80	21.24	21.53	27.34	31.79	26.28	23.08	25.00	30

[a] UPW* factors are reported for years 26-30 to accommodate a planning/construction period of up to 5 years. (See p. 6 for instructions on use.)

Table A-2. UPV factors for finding the present value of annually recurring uniform amounts (non-fuel)

Year of Occurrence (t)	Uniform Present Value (UPV) Factors: FEMP Discount rate 3.0%	OMB Discount Rates[a]: Short term[b] 2.5%	OMB Discount Rates[a]: Long Term[c] 2.8%
1	0.97	0.98	0.97
2	1.91	1.93	1.92
3	2.83	2.86	2.84
4	3.72	3.76	3.73
5	4.58	4.65	4.61
6	5.42	5.51	5.45
7	6.23	6.35	6.28
8	7.02	7.17	7.08
9	7.79	7.97	7.86
10	8.53	8.75	8.62
11	9.25		9.36
12	9.95		10.07
13	10.63		10.77
14	11.30		11.45
15	11.94		12.11
16	12.56		12.76
17	13.17		13.38
18	13.75		13.99
19	14.32		14.58
20	14.88		15.16
21	15.42		15.72
22	15.94		16.26
23	16.44		16.79
24	16.94		17.31
25	17.41		17.81
26	17.88		18.30
27	18.33		18.77
28	18.76		19.23
29	19.19		19.68
30	19.60		20.12

[a] OMB discount rates as of March 1994. OMB rates are expected to be revised in February 1995.
[b] Short-term discount rate based on OMB discount rate for 7-year study period.
[c] Long-term discount rate based on OMB discount rate for 30-year study period.

PRICE LIST - BAAP LEAK DETECTION STUDY

Item	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Comments
BACKFILL	CY	$0.00	$0.68	$0.56	Approx 2/3 CY per LF piping
BLIND FLANGE, 06"	EA	$107.00	$106.00	$0.00	250 PSI
BLIND FLANGE, 08"	EA	$163.00	$159.00	$0.00	250 PSI
BLIND FLANGE, 10"	EA	$350.00	$186.00	$0.00	250 PSI
BLIND FLANGE, 12"	EA	$470.00	$226.00	$0.00	250 PSI
BLIND FLANGE, 14"	EA	$745.00	$226.00	$0.00	250 PSI
BLIND FLANGE, 16"	EA	$865.00	$315.00	$0.00	250 PSI
BLIND FLANGE, 24"	EA	$2,425.00	$635.00	$0.00	250 PSI
COMPACTION	CY	$0.00	$0.82	$0.32	Walk behind vibrating plate
CRUSHED ROCK BEDDING	CY	$13.00	$3.28	$1.33	For pipe bedding, hydrant leakage
DEWATERING	DAY	$0.00	$67.50	$7.80	2" Diaphragm pump for 8 hours
ELBOW, 06"	EA	$121.00	$20.50	$0.00	
ELBOW, 08"	EA	$197.00	$24.50	$0.00	
ELBOW, 12"	EA	$335.00	$34.50	$5.75	
ELBOW, 14"	EA	$540.00	$38.50	$6.45	
ELBOW, 16"	EA	$610.00	$44.00	$7.40	
ELBOW, 24"	EA	$1,400.00	$103.00	$17.25	
EXCAVATION	CY	$0.00	$1.48	$1.51	Approx 2/3 CY per LF piping
GATE VALVE, 02"	EA	$300.00	$65.00	$0.00	Add $100 matl/$20 labor for valve box
GATE VALVE, 06"	EA	$465.00	$129.00	$0.00	With valve box
GATE VALVE, 08"	EA	$700.00	$177.00	$29.50	With valve box
GATE VALVE, 12"	EA	$1,200.00	$206.00	$34.50	With valve box
GATE VALVE, 14"	EA	$3,250.00	$310.00	$52.00	With valve box
GATE VALVE, 16"	EA	$4,250.00	$310.00	$52.00	With valve box
GATE VALVE, 24"	EA	$8,325.00	$1,250.00	$207.00	With valve box
HYDRANT	EA	$1,070.00	$88.50	$14.80	Add for three-way valve (7%)
HYDRANT DEMOLITION	EA	$0.00	$96.50	$0.00	
PATCH PIPE LEAK	EA	$200.00	$130.00	$0.00	Assume Crew B-20, 6 manhours
PAVEMENT REMOVAL, 3" THICK	SY	$0.00	$1.24	$1.79	
PIPE LINING, 06"	LF	$11.12	$18.60	$0.54	Sizes 6" - 10"
PIPE LINING, 10"	LF	$13.90	$19.10	$0.56	Sizes 10" - 12"
PIPE LINING, 12"	LF	$14.30	$21.70	$0.64	Sizes 12" - 16"

PRICE LIST - BAAP LEAK DETECTION STUDY

Item	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Comments
PIPE LINING, 16"	LF	$15.30	$26.70	$0.78	Sizes 16" - 20"
PIPE LINING, 24"	LF	$18.30	$28.60	$0.84	Sizes 24" - 36"
PIPE REMOVAL, TO 24" DIA.	LF	$0.00	$4.09	$1.66	
PIPE REMOVAL, TO 36" DIA.	LF	$0.00	$5.45	$2.22	
PIPE REMOVAL, TO 12" DIA.	LF	$0.00	$2.81	$1.14	
PIPING, 06"	LF	$8.45	$4.10	$0.00	
PIPING, 08"	LF	$11.15	$5.75	$0.96	
PIPING, 12"	LF	$18.50	$8.60	$1.44	
PIPING, 14"	LF	$23.00	$11.45	$1.92	
PIPING, 16"	LF	$25.50	$13.45	$2.25	
PIPING, 24"	LF	$45.50	$18.60	$4.32	
TEE, 06"	EA	$182.00	$30.50	$0.00	
TEE, 08"	EA	$258.00	$37.00	$0.00	
TEE, 14"	EA	$655.00	$62.00	$10.35	
TEE, 16"	EA	$920.00	$77.50	$12.95	
TEE, 24"	EA	$2,125.00	$206.00	$34.50	
THRUST BLOCK	CY	$81.50	$110.10	$0.00	
VALVE DEMOLITION, TO 16"	EA	$0.00	$50.00	$0.00	Includes valve box demo
VALVE DEMOLITION, TO 8"	EA	$0.00	$30.00	$0.00	Includes valve box demo
WELDING METAL PIPE	MAN-HR	$2.73	$28.50	$9.45	Cost per welder. Assume 2 welders.

*Note: Pipe lining costs include costs for pipe cleaning, protection of connections, lining placement, curing & protection of lining, and access openings

CITY COST INDEXES

DIVISION		VIRGINIA												WASHINGTON					
		NEWPORT NEWS			NORFOLK			RICHMOND			ROANOKE			SEATTLE			SPOKANE		
		MAT.	INST.	TOTAL	MAT.	INST.	TOTAL	MAT.	INST.	TOTAL	MAT.	INST.	TOTAL	MAT.	INST.	TOTAL	MAT.	INST.	TOTAL
2	SITE WORK	104.6	86.5	90.7	103.3	86.3	90.2	105.1	85.8	91.0	101.3	83.8	87.9	89.9	126.1	117.8	92.6	94.8	[illegible]
031	CONCRETE FORMWORK	94.9	60.9	66.1	100.4	60.9	66.9	96.1	61.2	66.5	94.9	50.1	55.9	89.0	102.2	100.2	113.3	91.5	[illegible]
032	CONCRETE REINFORCEMENT	97.0	65.7	79.3	97.0	65.7	79.3	97.0	63.9	78.3	97.0	63.6	78.1	100.2	99.5	99.8	105.7	98.9	[illegible]
033	CAST IN PLACE CONCRETE	102.2	64.5	86.0	102.2	64.5	86.0	105.1	62.9	87.5	102.0	56.6	82.5	93.4	109.2	100.2	107.5	93.1	[illegible]
3	CONCRETE	101.6	65.0	83.2	102.0	65.0	83.4	103.5	64.2	83.7	101.5	57.1	79.2	117.9	103.4	110.6	116.9	93.2	[illegible]
4	MASONRY	95.0	55.7	70.7	100.1	55.7	72.7	89.6	60.4	71.6	94.0	47.9	65.5	142.7	104.0	118.8	118.8	94.4	[illegible]
5	METALS	96.1	92.7	94.8	96.1	92.7	94.8	96.1	92.6	94.7	96.1	89.6	93.6	100.8	90.0	95.5	97.7	90.7	[illegible]
6	WOOD & PLASTICS	89.9	63.8	76.7	95.8	63.8	80.1	91.4	63.9	77.5	89.9	50.5	69.9	93.2	100.7	97.0	107.8	90.1	[illegible]
7	THERMAL & MOISTURE PROTECTION	92.1	55.7	75.1	92.4	55.7	75.3	92.0	55.1	74.8	92.1	52.5	73.7	108.3	97.9	103.5	172.0	87.6	[illegible]
8	DOORS & WINDOWS	96.0	60.9	87.6	96.0	60.9	87.6	96.0	59.0	87.1	96.0	51.5	85.3	109.4	99.4	107.0	119.1	89.8	[illegible]
092	LATH, PLASTER & GYPSUM BOARD	87.3	61.3	69.4	87.3	61.3	69.4	87.3	61.3	69.5	87.3	48.5	60.6	97.7	100.0	99.3	138.9	89.6	[illegible]
095	ACOUSTICAL TREATMENT & WOOD FLOORING	89.4	61.3	71.2	89.4	61.3	71.2	89.4	61.3	71.3	89.4	48.5	62.9	146.6	100.0	116.5	145.1	89.6	[illegible]
096	FLOORING & CARPET	82.8	54.3	76.1	82.8	54.3	76.1	82.8	75.0	80.9	82.8	48.7	74.8	123.6	100.0	118.1	131.3	85.2	[illegible]
099	PAINTING & WALL COVERINGS	100.8	58.8	76.7	100.8	58.8	76.7	100.8	48.6	70.8	100.8	45.9	69.3	124.1	95.3	107.6	130.1	83.4	[illegible]
9	FINISHES	87.4	59.7	73.3	87.4	59.7	73.3	87.3	62.9	74.9	87.2	49.1	67.8	133.6	100.7	116.9	149.5	89.1	[illegible]
10-14	TOTAL DIV. 10-14	100.0	76.5	94.9	100.0	76.5	94.9	100.0	75.5	94.7	100.0	71.6	93.8	100.0	105.7	101.2	100.0	97.6	[illegible]
15	MECHANICAL	99.9	58.6	82.3	99.8	58.3	82.1	99.9	66.0	85.4	99.9	57.3	81.7	99.9	111.5	104.9	101.8	95.3	[illegible]
16	ELECTRICAL	92.6	63.6	73.6	92.6	63.6	73.6	92.6	71.5	78.7	92.6	51.6	65.7	99.5	101.2	100.6	88.7	83.9	[illegible]
1-16	WEIGHTED AVERAGE	96.7	66.7	82.3	97.1	66.6	82.5	96.7	70.0	83.9	96.6	60.1	79.1	109.1	105.1	107.2	111.8	91.4	[illegible]

DIVISION		WASHINGTON			WEST VIRGINIA						WISCONSIN						WYOMING		
		TACOMA			CHARLESTON			HUNTINGTON			MADISON			MILWAUKEE			CHEYENNE		
		MAT.	INST.	TOTAL	MAT.	INST.	TOTAL	MAT.	INST.	TOTAL	MAT.	INST.	TOTAL	MAT.	INST.	TOTAL	MAT.	INST.	TOTAL
2	SITE WORK	89.9	126.0	117.6	99.7	86.7	89.7	101.3	86.9	90.3	74.2	101.1	94.9	74.6	90.7	87.0	90.0	99.4	[illegible]
031	CONCRETE FORMWORK	89.0	101.8	99.8	102.8	87.8	90.1	94.9	90.4	91.1	107.1	82.2	86.0	111.3	100.0	101.7	99.2	59.2	[illegible]
032	CONCRETE REINFORCEMENT	100.2	99.3	99.7	97.0	74.7	84.4	97.0	80.0	87.4	87.3	78.8	82.5	87.3	102.0	95.6	98.4	53.1	[illegible]
033	CAST IN PLACE CONCRETE	93.4	109.0	100.1	99.8	87.9	94.7	102.0	95.8	99.3	93.0	86.2	90.1	91.2	97.7	94.0	100.5	68.2	[illegible]
3	CONCRETE	117.9	103.0	110.4	101.1	86.6	93.8	101.5	91.5	96.5	86.7	83.3	85.0	86.5	98.5	92.5	104.6	61.9	[illegible]
4	MASONRY	142.7	101.0	117.0	93.5	84.8	88.1	94.0	86.0	89.1	89.2	83.0	85.4	89.1	102.7	97.5	92.7	54.2	[illegible]
5	METALS	100.8	89.3	96.4	96.1	101.5	98.2	96.1	103.6	98.9	98.4	85.2	93.4	98.4	83.7	92.8	105.1	69.9	[illegible]
6	WOOD & PLASTICS	92.1	100.7	96.4	100.2	88.8	94.4	89.9	91.5	90.7	113.5	83.2	98.1	118.4	98.6	108.4	97.5	58.8	[illegible]
7	THERMAL & MOISTURE PROTECTION	107.7	95.0	101.8	92.5	84.7	88.9	92.1	88.0	90.2	96.4	80.4	88.9	95.2	98.4	96.7	105.9	63.7	[illegible]
8	DOORS & WINDOWS	109.8	99.4	107.3	97.1	80.3	93.1	96.0	83.0	92.9	109.2	78.6	101.9	109.2	97.2	106.3	96.1	58.3	[illegible]
092	LATH, PLASTER & GYPSUM BOARD	97.3	100.0	99.2	87.3	88.2	87.9	87.3	91.0	89.8	105.7	83.1	90.1	105.7	99.0	101.1	90.9	57.1	[illegible]
095	ACOUSTICAL TREATMENT & WOOD FLOORING	145.1	100.0	115.9	89.4	88.2	88.6	89.4	91.0	90.4	107.9	83.1	91.9	107.9	99.0	102.1	96.4	57.1	[illegible]
096	FLOORING & CARPET	124.3	76.7	113.2	82.8	92.0	84.9	82.8	92.5	85.0	102.3	70.6	94.9	105.5	94.6	103.0	93.9	57.7	[illegible]
099	PAINTING & WALL COVERINGS	124.1	95.3	107.6	100.8	77.3	87.3	100.8	78.5	88.0	102.2	78.9	88.8	105.1	97.0	100.4	106.7	78.6	[illegible]
9	FINISHES	133.5	95.8	114.3	87.3	87.8	87.5	87.2	89.8	88.6	101.9	79.7	90.6	103.3	98.8	101.0	89.8	60.7	[illegible]
10-14	TOTAL DIV. 10-14	100.0	105.6	101.2	100.0	97.8	99.5	100.0	88.3	97.4	100.0	85.9	96.9	100.0	98.3	99.6	100.0	79.2	[illegible]
15	MECHANICAL	99.9	109.2	103.9	99.8	80.9	91.7	99.9	82.8	92.6	99.8	83.5	92.9	99.8	93.6	97.2	97.2	58.7	[illegible]
16	ELECTRICAL	99.5	93.9	95.8	92.6	86.0	88.3	92.6	88.7	90.0	90.8	80.5	84.1	92.3	101.4	98.3	99.5	66.5	[illegible]
1-16	WEIGHTED AVERAGE	109.1	102.4	105.9	96.7	86.8	91.9	96.6	88.8	92.8	97.4	84.2	91.1	97.7	95.2	97.0	98.5	66.1	[illegible]

DIVISION		CANADA																	
		EDMONTON, ALBERTA			MONTREAL, QUEBEC			QUEBEC, QUEBEC			TORONTO, ONTARIO			VANCOUVER, B C			WINNIPEG, MANITOBA		
		MAT.	INST.	TOTAL	MAT.	INST.	TOTAL	MAT.	INST.	TOTAL	MAT.	INST.	TOTAL	MAT.	INST.	TOTAL	MAT.	INST.	TOTAL
2	SITE WORK	102.7	100.7	101.1	88.5	100.6	97.8	88.5	100.6	97.8	110.8	100.8	103.2	96.8	101.5	100.4	106.8	99.4	[illegible]
031	CONCRETE FORMWORK	112.8	99.9	101.8	126.0	102.6	106.1	126.0	102.7	106.2	116.9	124.2	123.1	107.0	108.1	107.9	115.8	93.3	[illegible]
032	CONCRETE REINFORCEMENT	151.1	81.2	115.9	147.8	93.2	116.9	147.8	93.2	116.9	174.4	95.8	130.0	161.1	105.5	129.7	161.1	73.1	[illegible]
033	CAST IN PLACE CONCRETE	139.5	95.7	120.7	129.1	108.4	120.2	129.1	108.5	120.2	166.7	121.6	147.3	121.3	111.9	117.3	150.2	91.1	[illegible]
3	CONCRETE	133.9	95.0	114.3	128.3	102.8	115.5	128.3	102.8	115.5	148.7	117.5	133.0	131.9	108.7	120.2	132.2	89.1	[illegible]
4	MASONRY	146.0	98.1	116.4	143.5	106.0	120.3	143.5	106.0	120.3	149.6	126.0	135.0	144.7	115.6	125.8	146.8	90.5	[illegible]
5	METALS	101.0	93.7	98.2	101.0	97.4	99.6	101.0	97.5	99.7	101.0	107.0	103.3	101.0	102.5	101.6	101.0	92.3	[illegible]
6	WOOD & PLASTICS	113.0	99.6	106.2	134.6	102.6	118.4	134.6	102.6	118.4	120.0	124.5	122.3	103.9	105.9	104.9	117.5	94.6	[illegible]
7	THERMAL & MOISTURE PROTECTION	103.6	96.5	100.3	104.0	105.0	104.4	104.0	105.0	104.4	103.7	114.2	108.6	103.5	106.7	105.0	103.7	91.9	[illegible]
8	DOORS & WINDOWS	90.4	92.8	91.0	90.4	89.7	90.2	90.4	95.5	91.6	89.7	119.6	96.8	90.4	103.2	93.5	90.4	85.8	[illegible]
092	LATH, PLASTER & GYPSUM BOARD	146.6	99.6	114.3	216.6	102.7	138.4	216.6	102.7	138.4	162.9	125.3	137.1	154.5	106.1	121.3	144.7	94.4	[illegible]
095	ACOUSTICAL TREATMENT & WOOD FLOORING	106.2	99.6	101.9	106.2	102.7	104.0	106.2	102.7	104.0	105.2	125.3	118.6	105.2	106.1	106.2	106.2	94.4	[illegible]
096	FLOORING & CARPET	132.6	94.4	123.6	132.6	114.0	128.2	132.6	114.0	128.2	132.6	118.2	129.2	132.6	105.9	126.3	132.6	87.5	[illegible]
099	PAINTING & WALL COVERINGS	110.6	95.4	101.9	110.6	109.1	109.8	110.6	109.1	109.8	110.6	126.9	119.9	110.6	109.6	110.0	110.6	79.9	[illegible]
9	FINISHES	120.1	98.9	109.3	126.6	105.8	116.0	126.6	105.5	116.0	121.5	124.2	122.8	120.9	107.7	114.2	119.9	91.0	[illegible]
10-14	TOTAL DIV. 10-14	100.0	102.6	100.6	100.0	106.7	101.5	100.0	105.7	101.5	100.0	104.7	101.0	100.0	106.2	101.3	100.0	90.9	[illegible]
15	MECHANICAL	101.2	90.1	96.5	101.3	99.2	100.4	101.3	99.2	100.4	101.1	119.7	109.0	101.2	109.9	104.9	101.2	94.9	[illegible]
16	ELECTRICAL	131.6	100.7	111.3	131.6	101.5	111.9	131.6	101.5	111.9	131.6	122.7	125.8	131.6	99.6	110.6	131.6	101.3	[illegible]
1-16	WEIGHTED AVERAGE	110.8	96.4	103.9	110.6	101.4	106.2	110.6	101.7	106.3	113.2	117.4	115.2	110.3	106.3	108.4	110.8	94.0	[illegible]

SITE WORK

020 550 | Site Demolition

020 550	Site Demolition	CREW	DAILY OUTPUT	MAN-HOURS	UNIT	1994 BARE COSTS MAT.	LABOR	EQUIP.	TOTAL	TOTAL INCL O&P
554 0850	Remove and reset	2 Clab	35	.457	L.F.		8.70		8.70	13.75 554
0860	Guide posts, remove only	B-55	90	.267	Ea.		5.10	6.55	11.65	15.20
0870	Remove and reset	"	50	.480			9.20	11.80	21	27.50
0900	Hydrants, fire, remove only	2 Plum	4.70	3.404			96.50		96.50	147
0901	Hydrants, fire, remove only	2 Skwk	4.70	3.404			84		84	133
0950	Remove and reset	2 Plum	1.40	11.429			325		325	495
0951	Remove and reset	2 Skwk	1.40	11.429			282		282	445
0952	Hydrants, fire, remove and reset	2 Plum	1.40	11.429			325		325	495
1000	Masonry walls, block or tile, solid, remove	B-5	1,800	.036	C.F.		.76	.52	1.28	1.76
1100	Cavity wall		2,200	.029			.62	.42	1.04	1.45
1200	Brick, solid		900	.071			1.53	1.04	2.57	3.52
1300	With block back-up		1,130	.057			1.22	.83	2.05	2.81
1400	Stone, with mortar		900	.071			1.53	1.04	2.57	3.52
1500	Dry set		1,500	.043			.92	.62	1.54	2.11
1600	Median barrier, precast concrete, remove and store	B-3	430	.112	L.F.		2.28	3.68	5.96	7.60
1610	Remove and reset	"	390	.123	"		2.52	4.06	6.58	8.40
1710	Pavement removal, bituminous, 3" thick	B-38	690	.058	S.Y.		1.24	1.79	3.03	3.90
1750	4" to 6" thick		420	.095			2.03	2.94	4.97	6.40
1800	Bituminous driveways		680	.059			1.26	1.82	3.08	3.96
1900	Concrete to 6" thick, mesh reinforced		255	.157			3.35	4.85	8.20	10.60
2000	Rod reinforced		200	.200			4.27	6.20	10.47	13.45
2100	Concrete 7" to 24" thick, plain		13.10	3.053	C.Y.		65	94.50	159.50	206
2200	Reinforced		9.50	4.211	"		90	130	220	283
2210	Patio/carport, not incl. foundation	2 Clab	1,066	.015	S.F.		.29		.29	.45
2220	Roof cover only	1 Carp	1,000	.008			.19		.19	.30
2230	Remove and reset roof cover		320	.025			.59		.59	.94
2240	Column only		53	.151	Ea.		3.59		3.59	5.70
2300	With hand held air equipment, bituminous	B-39	1,900	.025	S.F.		.51	.08	.59	.89
2320	Concrete to 6" thick, no reinforcing		1,200	.040			.80	.12	.92	1.40
2340	Mesh reinforced		830	.058			1.16	.18	1.34	2.03
2360	Rod reinforced		765	.063			1.26	.19	1.45	2.19
2400	Curbs, concrete, plain	B-6	325	.074	L.F.		1.51	.61	2.12	3.05
2500	Reinforced		220	.109			2.23	.91	3.14	4.49
2600	Granite curbs		355	.068			1.38	.56	1.94	2.79
2700	Bituminous curbs		830	.029			.59	.24	.83	1.19
2800	Wood		570	.042			.86	.35	1.21	1.74
2900	Pipe removal, concrete, no excavation, 12" diameter		175	.137			2.81	1.14	3.95	5.65
2930	15" diameter		150	.160			3.28	1.33	4.61	6.55
2960	24" diameter		120	.200			4.09	1.66	5.75	8.25
3000	36" diameter		90	.267			5.45	2.22	7.67	11
3200	Steel, welded connections, 4" diameter		160	.150			3.07	1.25	4.32	6.15
3300	10" diameter		80	.300			6.15	2.50	8.65	12.35
3500	Railroad track removal, ties and track	B-14	110	.436			8.75	1.82	10.57	15.80
3600	Ballast		500	.096	C.Y.		1.93	.40	2.33	3.47
3700	Remove and re-install ties & track using new bolts & spikes		50	.960	L.F.		19.25	3.99	23.24	35
3800	Turnouts using new bolts and spikes		1	48	Ea.		965	200	1,165	1,750
4000	Sidewalk removal, bituminous, 2-1/2" thick	B-6	325	.074	S.Y.		1.51	.61	2.12	3.05
4050	Brick, set in mortar		185	.130			2.66	1.08	3.74	5.35
4060	Dry set		270	.089			1.82	.74	2.56	3.66
4100	Concrete, plain		160	.150			3.07	1.25	4.32	6.15
4200	Mesh reinforced		150	.160			3.28	1.33	4.61	6.55
5000	Slab on grade removal, plain	B-5	45	1.422	C.Y.		30.50	20.50	51	70.50
5100	Mesh reinforcing		33	1.939			41.50	28.50	70	96
5200	Rod reinforcing		25	2.560			55	37.50	92.50	127
5500	For congested sites or small quantities, add up to								200%	200%
5550	For disposal on site, add	B-11A	232	.069			1.50	3.53	5.03	6.20

021 | Site Preparation and Excavation Support

021 100 | Site Clearing

Ref	No.	Description	Crew	Daily Output	Man-Hours	Unit	Mat.	Labor	Equip.	Total	Total Incl O&P
							1994 Bare Costs				
116	1700	24" to 36" diameter, softwood	B-10M	100	.120	Ea.		2.71	9.95	12.66	15.15
	1750	Hardwood		50	.240			5.40	19.90	25.30	30.50
	1800	36" to 48" diameter, softwood		70	.171			3.87	14.20	18.07	21.50
	1850	Hardwood		35	.343			7.75	28.50	36.25	43.50

021 140 | Stripping

Ref	No.	Description	Crew	Daily Output	Man-Hours	Unit	Mat.	Labor	Equip.	Total	Total Incl O&P
144	0010	STRIPPING Topsoil, and stockpiling, sandy loam									
	0020	200 H.P. dozer, ideal conditions	B-10B	2,300	.005	C.Y.		.12	.36	.48	.57
	0100	Adverse conditions	•	1,150	.010			.24	.71	.95	1.14
	0200	300 HP dozer, ideal conditions	B-10M	3,000	.004			.09	.33	.42	.51
	0300	Adverse conditions	•	1,650	.007			.16	.60	.76	.91
	0400	400 HP dozer, ideal conditions	B-10X	3,900	.003			.07	.32	.39	.46
	0500	Adverse conditions	•	2,000	.006			.14	.63	.77	.90
	0600	Clay, dry and soft, 200 HP dozer, ideal conditions	B-10B	1,600	.008			.17	.51	.68	.82
	0601	Strip topsoil, clay, dry & soft, 200 HP dozer, ideal conditions		1,600	.008			.17	.51	.68	.82
	0700	Adverse conditions		800	.015			.34	1.02	1.36	1.65
	1000	Medium hard, 300 HP dozer, ideal conditions	B-10M	2,000	.006			.14	.50	.64	.76
	1100	Adverse conditions	•	1,100	.011			.25	.91	1.16	1.38
	1200	Very hard, 400 HP dozer, ideal conditions	B-10X	2,600	.005			.10	.48	.58	.69
	1300	Adverse conditions	•	1,340	.009			.20	.94	1.14	1.34

021 150 | Selective Clearing

Ref	No.	Description	Crew	Daily Output	Man-Hours	Unit	Mat.	Labor	Equip.	Total	Total Incl O&P
154	0010	SELECTIVE CLEARING									
	1000	Stump removal on site by hydraulic backhoe, 1-1/2 C.Y.									
	1050	8" to 12" diameter	B-30	33	.727	Ea.		15.45	45	60.45	73.50
	1100	14" to 24" diameter		25	.960			20.50	59	79.50	96.50
	1150	26" to 36" diameter		16	1.500			32	92.50	124.50	151
	1151	Stump removal, 19" to 24" diameter		16	1.500			32	92.50	124.50	151
	2000	Remove selective trees, on site using chain saws and chipper,									
	2050	not incl. stumps, up to 6" diameter	B-7	18	2.667	Ea.		54	59.50	113.50	151
	2100	8" to 12" diameter		12	4			81	89.50	170.50	225
	2150	14" to 24" diameter		10	4.800			97	107	204	271
	2200	26" to 36" diameter		8	6			121	134	255	340
	2300	Machine load, 2 mile haul to dump, 12" diam. tree, add								40	60

021 200 | Structure Moving

Ref	No.	Description	Crew	Daily Output	Man-Hours	Unit	Mat.	Labor	Equip.	Total	Total Incl O&P
204	0010	MOVING BUILDINGS One day move, up to 24' wide									
	0020	Reset on new foundation, patch & hook-up, average move				Total					8,500
	0040	Wood or steel frame bldg., based on ground floor area	B-4	185	.259	S.F.		5.05	2.35	7.40	10.55
	0060	Masonry bldg., based on ground floor area	•	137	.350			6.80	3.17	9.97	14.25
	0200	For 24' to 42' wide, add									15%
	0220	For each additional day on road, add	B-4	1	48	Day		935	435	1,370	1,950
	0240	Construct new basement, move building, 1 day									
	0300	move, patch & hook-up, based on ground floor area	B-3	155	.310	S.F.	5.30	6.35	10.20	21.85	27

021 400 | Dewatering

Ref	No.	Description	Crew	Daily Output	Man-Hours	Unit	Mat.	Labor	Equip.	Total	Total Incl O&P
404	0010	DEWATERING Excavate drainage trench, 2' wide, 2' deep	B-11C	90	.178	C.Y.		3.85	2.22	6.07	8.45
	0100	2' wide, 3' deep, with backhoe loader	•	135	.119			2.57	1.48	4.05	5.65
	0200	Excavate sump pits by hand, light soil	1 Clab	7.10	1.127			21.50		21.50	34
	0300	Heavy soil	•	3.50	2.286			43.50		43.50	69
	0500	Pumping 8 hr., attended 2 hrs. per day, including 20 L.F.									
	0550	of suction hose & 100 L.F. discharge hose									
	0600	2" diaphragm pump used for 8 hours	B-10H	4	3	Day		67.50	7.80	75.30	114
	0620	Add per additional pump							30	26	33
	0650	4" diaphragm pump used for 8 hours	B-10I	4	3			67.50	19.90	87.40	127
	0670	Add per additional pump							63	68	69

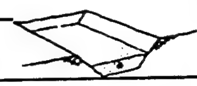
025 | Paving and Surfacing

025 800 | Pavement Marking

			CREW	DAILY OUTPUT	MAN-HOURS	UNIT	1994 BARE COSTS MAT.	LABOR	EQUIP.	TOTAL	TOTAL INCL O&P
810	0250	9-1/4"x5-7/8"x1/4" high, plowable, asphalt pav't	A-2A	120	.200	Ea.	1.55	3.83	2.16	7.54	10.10
	0300	Barrier and curb delineators, reflectorized, 2"x4"	2 Clab	150	.107		1.05	2.03		3.08	4.36
	0310	3"x5"	•	150	.107		2.35	2.03		4.38	5.80
	0500	Rumble strip, polycarbonate									
	0510	24"x3-1/2"x1/2" high	2 Clab	50	.320	Ea.	4.35	6.10		10.45	14.45

026 | Piped Utilities

026 010 | Piped Utilities



			CREW	DAILY OUTPUT	MAN-HOURS	UNIT	1994 BARE COSTS MAT.	LABOR	EQUIP.	TOTAL	TOTAL INCL O&P
012	0010	BEDDING For pipe and conduit, not incl. compaction									
	0050	Crushed or screened bank run gravel	B-6	150	.160	C.Y.	12.55	3.28	1.33	17.16	20.50
	0100	Crushed stone 3/4" to 1/2"		150	.160		13	3.28	1.33	17.61	21
	0200	Sand, dead or bank,		150	.160		3.75	3.28	1.33	8.36	10.70
	0500	Compacting bedding in trench	A-1	90	.089			1.69	.65	2.34	3.39
014	0010	EXCAVATION AND BACKFILL See division 022-204 & 254									
	0100	Hand excavate and trim for pipe bells after trench excavation									
	0200	8" pipe	1 Clab	155	.052	L.F.		.98		.98	1.55
	0300	18" pipe	•	130	.062	•		1.17		1.17	1.85

026 050 | Manholes & Cleanouts

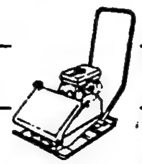
			CREW	DAILY OUTPUT	MAN-HOURS	UNIT	1994 BARE COSTS MAT.	LABOR	EQUIP.	TOTAL	TOTAL INCL O&P
054	0010	UTILITY VAULTS Precast concrete, 6" thick									
	0040	4' x 6' x 6' high, I.D.	B-13	2	28	Ea.	1,300	575	246	2,121	2,600
	0050	5' x 10' x 6' high, I.D.		2	28		1,600	575	246	2,421	2,950
	0100	6' x 10' x 6' high, I.D.		2	28		1,675	575	246	2,496	3,000
	0150	5' x 12' x 6' high, I.D.		2	28		1,775	575	246	2,596	3,125
	0200	6' x 12' x 6' high, I.D.		1.80	31.111		1,975	635	273	2,883	3,475
	0250	6' x 13' x 6' high, I.D.		1.50	37.333		2,600	765	330	3,695	4,400
	0300	8' x 14' x 7' high, I.D.		1	56		2,800	1,150	490	4,440	5,450
	0350	Hand hole, precast concrete, 1-1/2" thick									
	0400	1'-0" x 2'-0" x 1'-9", I.D., light duty	B-1	4	6	Ea.	275	118		393	490
	0450	4'-6" x 3'-2" x 2'-0", O.D., heavy duty	B-6	3	8		525	164	66.50	755.50	910
	0460	Meter pit, 4' x 4', 4' deep		2	12		850	246	100	1,196	1,425
	0470	6' deep		1.60	15		1,200	305	125	1,630	1,950
	0480	8' deep		1.40	17.143		1,600	350	143	2,093	2,450
	0490	10' deep		1.20	20		2,025	410	166	2,601	3,050
	0500	15' deep		1	24		2,950	490	200	3,640	4,250
	0510	6' x 6', 4' deep		1.40	17.143		900	350	143	1,393	1,700
	0520	6' deep		1.20	20		1,350	410	166	1,926	2,300
	0530	8' deep		1	24		1,800	490	200	2,490	2,975
	0540	10' deep		.80	30		2,250	615	250	3,115	3,700
	0550	15' deep		.60	40		3,425	820	335	4,580	5,400

026 100 | Pipe & Fittings

			CREW	DAILY OUTPUT	MAN-HOURS	UNIT	1994 BARE COSTS MAT.	LABOR	EQUIP.	TOTAL	TOTAL INCL O&P
104	0010	PIPE INSULATION									
	0100	Calcium silicate, 1" thick, 4" diameter	Q-14	150	.107	L.F.	2.80	2.58		5.38	7.25
	0120	5" diameter		145	.110		3.08	2.67		5.75	7.70
	0140	6" diameter		140	.114		3.22	2.77		5.99	8

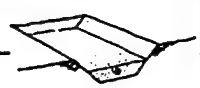
See the Reference Section for reference number information, Crew Listings and City Cost Indexes

		022 200 | Excav./Backfill/Compact.	CREW	DAILY OUTPUT	MAN-HOURS	UNIT	1994 BARE COSTS MAT.	LABOR	EQUIP.	TOTAL	TOTAL INCL O&P
226	6210	3 passes	B-10C	1,735	.007	C.Y.		.16	.53	.69	.82
	6220	4 passes		1,300	.009			.21	.71	.92	1.10
	6250	12" lifts, 2 passes		5,200	.002			.05	.18	.23	.27
	6260	3 passes		3,465	.003			.08	.27	.35	.41
	6270	4 passes		2,600	.005			.10	.35	.45	.55
	7000	Walk behind, vibrating plate 18" wide, 6" lifts, 2 passes	A-1	280	.029			.54	.21	.75	1.09
	7020	3 passes		185	.043			.82	.32	1.14	1.65
	7040	4 passes		140	.057			1.09	.42	1.51	2.18
	7200	12" lifts, 2 passes		560	.014			.27	.10	.37	.54
	7220	3 passes		375	.021			.41	.16	.57	.81
	7240	4 passes		280	.029			.54	.21	.75	1.09
	7500	Vibrating roller 24" wide, 6" lifts, 2 passes	B-10A	420	.029			.64	.19	.83	1.21
	7520	3 passes		280	.043			.97	.29	1.26	1.82
	7540	4 passes		210	.057			1.29	.39	1.68	2.43
	7600	12" lifts, 2 passes		840	.014			.32	.10	.42	.61
	7620	3 passes		560	.021			.48	.15	.63	.91
	7640	4 passes		420	.029			.64	.19	.83	1.21
	8000	Rammer tamper, 6" to 11", 4" lifts, 2 passes	A-1	130	.062			1.17	.45	1.62	2.34
	8050	3 passes		97	.082			1.57	.60	2.17	3.14
	8100	4 passes		65	.123			2.34	.90	3.24	4.69
	8200	8" lifts, 2 passes		260	.031			.58	.22	.80	1.18
	8250	3 passes		195	.041			.78	.30	1.08	1.56
	8300	4 passes		130	.062			1.17	.45	1.62	2.34
	8400	13" to 18", 4" lifts, 2 passes		390	.021			.39	.15	.54	.78
	8450	3 passes		290	.028			.52	.20	.72	1.05
	8500	4 passes		195	.041			.78	.30	1.08	1.56
	8600	8" lifts, 2 passes		780	.010			.19	.07	.26	.39
	8650	3 passes		585	.014			.26	.10	.36	.52
	8700	4 passes		390	.021			.39	.15	.54	.78
230	0010	DRILLING ONLY 2" hole for rock bolts, average	B-47	395	.061	L.F.		1.28	1.38	2.66	3.53
	0800	2-1/2" hole for pre-splitting, average		540	.044			.94	1.01	1.95	2.58
	1600	Quarry operations, 2-1/2" to 3-1/2" diameter		715	.034			.71	.76	1.47	1.95
	1610	6" diameter drill holes	B-47A	1,350	.018			.40	.32	.72	.97
234	0010	DRILLING AND BLASTING Only, rock, open face, under 1500 C.Y.	B-47	225	.107	C.Y.	1.35	2.25	2.42	6.02	7.70
	0100	Over 1500 C.Y.	"	300	.080		1.35	1.69	1.81	4.85	6.15
	0300	Bulk drilling and blasting, can vary greatly, average									3.65
	0500	Pits, average									18.75
	1300	Deep hole method, up to 1500 C.Y.	B-47	50	.480		1.35	10.15	10.90	22.40	29.50
	1400	Over 1500 C.Y.		66	.364		1.35	7.70	8.25	17.30	22.50
	1900	Restricted areas, up to 1500 C.Y.		13	1.846		1.35	39	42	82.35	108
	2000	Over 1500 C.Y.		20	1.200		1.35	25.50	27	53.85	71
	2200	Trenches, up to 1500 C.Y.		22	1.091		1.35	23	24.50	48.85	64.50
	2300	Over 1500 C.Y.		26	.923		1.35	19.50	21	41.85	55
	2500	Pier holes, up to 1500 C.Y.		22	1.091		1.35	23	24.50	48.85	64.50
	2600	Over 1500 C.Y.		31	.774		1.35	16.35	17.55	35.25	46.50
	2800	Boulders under 1/2 C.Y., loaded on truck, no hauling	B-100	80	.150			3.39	5.90	9.29	11.75
	2900	Drilled, blasted and loaded on truck, no hauling	B-47	30	.800		1.35	16.90	18.15	36.40	48
	3100	Jackhammer operators with foreman compressor, air tools	B-9	1	40	Day		775	148	923	1,375
	3300	Track drill, compressor, operator and foreman	B-47	1	24	"		505	545	1,050	1,400
	3500	Blasting caps				Ea.	1.90			1.90	2.09
	3700	Explosives				Lb.	1.35			1.35	1.49
	3900	Blasting mats, rent, for first day				Ea.	71			71	78
	4000	Per added day					22.50			22.50	25
	4200	Preblast survey for 6 room house, individual lot, minimum	A-6	2.40	6.667			147		147	226
	4300	Maximum	"	1.35	11.852			262		262	400



2 SITE WORK

022 200 | Excav./Backfill/Compact.

		022 200 Excav./Backfill/Compact.	CREW	DAILY OUTPUT	MAN-HOURS	UNIT	1994 BARE COSTS				TOTAL INCL O&P
							MAT.	LABOR	EQUIP.	TOTAL	
250	2000	Machine excavation, for spread and mat footings, elevator pits,									
	2001	and small building foundations									
	2035	Common earth, hydraulic backhoe, 3/4 C.Y. bucket	B-12F	90	.178	C.Y.		4.10	4.80	8.90	11.60
	2040	1 C.Y. bucket	B-12A	108	.148			3.42	4.89	8.31	10.65
	2050	1-1/2 C.Y. bucket	B-12B	144	.111			2.56	4.73	7.29	9.15
	2060	2 C.Y. bucket	B-12C	200	.080			1.85	4.68	6.53	8
	2070	Sand and gravel, 3/4 C.Y. bucket	B-12F	100	.160			3.69	4.32	8.01	10.40
	2080	1 C.Y. bucket	B-12A	120	.133			3.08	4.41	7.49	9.55
	2090	1-1/2 C.Y. bucket	B-12B	160	.100			2.31	4.26	6.57	8.20
	3000	2 C.Y. bucket	B-12C	220	.073			1.68	4.25	5.93	7.25
	3010	Clay, till, or blasted rock, 3/4 C.Y. bucket	B-12F	80	.200			4.62	5.40	10.02	13.05
	3020	1 C.Y. bucket	B-12A	95	.168			3.89	5.55	9.44	12.05
	3030	1-1/2 C.Y. bucket	B-12B	130	.123			2.84	5.25	8.09	10.10
	3040	2 C.Y. bucket	B-12C	175	.091			2.11	5.35	7.46	9.15
	9010	For mobilization or demobilization, see div. 022-274									
	9020	For dewatering, see div. 021-404									
	9022	For larger structures, see Bulk Excavation, div. 022-238									
	9024	For loading onto trucks, add								15%	
	9026	For hauling, see div. 022-266									
	9030	For sheeting or soldier beams & lagging, see div. 021-614 & 624									
	9040	For trench excavation of strip footings, see div. 022-254									
254	0010	EXCAVATING, TRENCH or continuous footing, common earth R022-240									
	0020	No sheeting or dewatering included									
	0050	1' to 4' deep, 3/8 C.Y. tractor loader/backhoe	B-11C	150	.107	C.Y.		2.31	1.33	3.64	5.05
	0060	1/2 C.Y. tractor loader/backhoe	B-11M	200	.080			1.73	1.37	3.10	4.20
	0062	3/4 C.Y. hydraulic backhoe	B-12F	270	.059			1.37	1.60	2.97	3.86
	0090	4' to 6' deep, 1/2 C.Y. tractor loader/backhoe	B-11M	200	.080			1.73	1.37	3.10	4.20
	0100	5/8 C.Y. hydraulic backhoe	B-12Q	250	.064			1.48	1.51	2.99	3.94
	0110	3/4 C.Y. hydraulic backhoe 	B-12F	300	.053			1.23	1.44	2.67	3.47
	0120	1 C.Y. hydraulic backhoe	B-12A	400	.040			.92	1.32	2.24	2.87
	0130	1-1/2 C.Y. hydraulic backhoe	B-12B	540	.030			.68	1.26	1.94	2.44
	0300	1/2 C.Y. hydraulic excavator, truck mounted	B-12J	200	.080			1.85	3.02	4.87	6.15
	0500	6' to 10' deep, 3/4 C.Y. hydraulic backhoe	B-12F	225	.071			1.64	1.92	3.56	4.63
	0510	1 C.Y. hydraulic backhoe	B-12A	400	.040			.92	1.32	2.24	2.87
	0600	1 C.Y. hydraulic excavator, truck mounted	B-12K	400	.040			.92	2.08	3	3.71
	0610	1-1/2 C.Y. hydraulic backhoe	B-12B	600	.027			.62	1.14	1.76	2.19
	0620	2-1/2 C.Y. hydraulic backhoe	B-12S	1,000	.016			.37	1.67	2.04	2.41
	0900	10' to 14' deep, 3/4 C.Y. hydraulic backhoe	B-12F	200	.080			1.85	2.16	4.01	5.20
	0910	1 C.Y. hydraulic backhoe	B-12A	360	.044			1.03	1.47	2.50	3.19
	1000	1-1/2 C.Y. hydraulic backhoe	B-12B	540	.030			.68	1.26	1.94	2.44
	1020	2-1/2 C.Y. hydraulic backhoe	B-12S	1,000	.016			.37	1.67	2.04	2.41
	1030	3 C.Y. hydraulic backhoe	B-12D	1,400	.011			.26	1.50	1.76	2.05
	1300	14' to 20' deep, 1 C.Y. hydraulic backhoe	B-12A	320	.050			1.15	1.65	2.80	3.59
	1310	1-1/2 C.Y. hydraulic backhoe	B-12B	480	.033			.77	1.42	2.19	2.74
	1320	2-1/2 C.Y. hydraulic backhoe	B-12S	850	.019			.43	1.96	2.39	2.83
	1330	3 C.Y. hydraulic backhoe	B-12D	1,000	.016			.37	2.10	2.47	2.88
	1400	By hand with pick and shovel to 6' deep, light soil	1 Clab	8	1			19		19	30
	1500	Heavy soil	"	4	2			38		38	60
	1700	For tamping backfilled trenches, air tamp, add	A-1	100	.080			1.52	.58	2.10	3.05
	1900	Vibrating plate, add		90	.089			1.69	.65	2.34	3.39
	2100	Trim sides and bottom for concrete pours, common earth		600	.013	S.F.		.25	.10	.35	.51
	2300	Hardpan		180	.044	"		.84	.32	1.16	1.70
	2400	Pier and spread footing excavation, add to above				C.Y.				30%	30%
	3000	Backfill trench, F.E. loader, wheel mtd., 1 C.Y. bucket									
	3020	Minimal haul	B-10R	400	.030	C.Y.		.68	.56	1.24	1.67

026 100 | Pipe & Fittings

Ref.	Line No.	Description	Crew	Daily Output	Man-Hours	Unit	1994 Bare Costs Mat.	Labor	Equip.	Total	Total Incl O&P
108	6210	18" diameter				L.F.				2.50	2.75
	6220	20" diameter								2.70	2.97
	6230	24" diameter								3.15	3.45
	6240	30" diameter								3.55	3.90
	6250	36" diameter								3.95	4.35
	6260	48" diameter								4.35	4.75
	6270	60" diameter								5.25	5.75
	6280	72" diameter								5.75	6.30
	9000	Inspection, television camera with film									
	9060	500 linear feet				Total				850	935

026 400 | Valves & Cocks

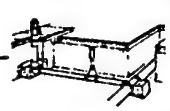
Ref.	Line No.	Description	Crew	Daily Output	Man-Hours	Unit	1994 Bare Costs Mat.	Labor	Equip.	Total	Total Incl O&P
404	0010	PIPING VALVES Water distribution, see also div. 151-900									
	3000	Butterfly valves with boxes, cast iron, mech. jt.									
	3100	4" diameter	B-20	6	4	Ea.	300	86		386	465
	3140	6" diameter	"	5	4.800		345	103		448	545
	3180	8" diameter	B-21	4	7		420	155	26	601	735
	3300	10" diameter		3.50	8		615	177	29.50	821.50	985
	3340	12" diameter		3	9.333		805	206	34.50	1,045.50	1,250
	3400	14" diameter		2	14		1,375	310	52	1,737	2,075
	3440	16" diameter		2	14		1,850	310	52	2,212	2,575
	3460	18" diameter		1.50	18.667		2,300	415	69	2,784	3,275
	3480	20" diameter		1	28		2,900	620	104	3,624	4,300
	3500	24" diameter		.50	56		4,050	1,250	207	5,507	6,625
	3600	With lever operator									
	3610	4" diameter	B-20	6	4	Ea.	200	86		286	355
	3614	6" diameter	"	5	4.800		280	103		383	475
	3616	8" diameter	B-21	4	7		405	155	26	586	720
	3618	10" diameter		3.50	8		650	177	29.50	856.50	1,025
	3620	12" diameter		3	9.333		1,200	206	34.50	1,440.50	1,700
	3622	14" diameter		2	14		1,925	310	52	2,287	2,675
	3624	16" diameter		2	14		2,625	310	52	2,987	3,425
	3626	18" diameter		1.50	18.667		3,000	415	69	3,484	4,025
	3628	20" diameter		1	28		4,000	620	104	4,724	5,500
	3630	24" diameter		.50	56		4,300	1,250	207	5,757	6,925
	3700	Check valves, flanged									
	3710	4" diameter	B-20	6	4	Ea.	225	86		311	385
	3712	5" diameter		5	4.800		385	103		488	585
	3714	6" diameter		5	4.800		380	103		483	585
	3716	8" diameter	B-21	4	7		775	155	26	956	1,125
	3718	10" diameter		3.50	8		1,250	177	29.50	1,456.50	1,650
	3720	12" diameter		3	9.333		1,900	206	34.50	2,140.50	2,475
	3722	14" diameter		2	14		3,050	310	52	3,412	3,900
	3724	16" diameter		2	14		4,175	310	52	4,537	5,150
	3726	18" diameter		1.50	18.667		6,200	415	69	6,684	7,525
	3728	20" diameter		1	28		7,200	620	104	7,924	9,025
	3730	24" diameter		.50	56		10,400	1,250	207	11,857	13,600
	3800	Gate valves, flanged									
	3810	4" diameter	B-20	6	4	Ea.	195	86		281	350
	3814	6" diameter	"	5	4.800		370	103		473	575
	3816	8" diameter	B-21	4	7		665	155	26	846	1,000
	3818	10" diameter		3.50	8		1,125	177	29.50	1,331.50	1,550
	3820	12" diameter		3	9.333		1,600	206	34.50	1,840.50	2,125
	3822	14" diameter		2	14		2,950	310	52	3,312	3,800
	3824	16" diameter		1	28		4,300	620	104	5,024	5,850
	3826	18" diameter		.80	35		6,425	775	130	7,330	8,425

See the Reference Section for reference number Information, Crew Listings and City Cost Indexes

026 400 | Valves & Cocks

	Description	Crew	Daily Output	Man-Hours	Unit	1994 Bare Costs Mat.	Labor	Equip.	Total	Total Incl. O&P	
3828	20" diameter	B-21	.80	35	Ea.	8,500	775	130	9,405	10,700	404
38	24" diameter		.50	56		11,700	1,250	207	13,157	15,100	
3	30" diameter		.35	80		24,800	1,775	296	26,871	30,400	
383	36" diameter		.30	93.333		31,600	2,075	345	34,020	38,400	
3840	With boxes Gate valve										
3842	4" diameter	B-20	5	4.800	Ea.	365	103		468	565	
3844	6" diameter		4	6		465	129		594	715	
3846	8" diameter	B-21	3.50	8		700	177	29.50	906.50	1,075	
3848	10" diameter		3	9.333		1,000	206	34.50	1,240.50	1,475	
3850	12" diameter		3	9.333		1,200	206	34.50	1,440.50	1,700	
3852	14" diameter		2	14		3,250	310	52	3,612	4,125	
3854	16" diameter		2	14		4,250	310	52	4,612	5,225	
3856	18" diameter		1.50	18.667		6,300	415	69	6,784	7,650	
3858	20" diameter		1	28		8,325	620	104	9,049	10,200	
3860	24" diameter		.50	56		8,325	1,250	207	9,782	11,300	
3880	Sleeve, for tapping mains, 8" x 4", add					400			400	440	
3900	Globe valves, flanged, iron body, class 125										
3910	4" diameter	B-20	10	2.400	Ea.	325	51.50		376.50	440	
3912	5" diameter		10	2.400		565	51.50		616.50	700	
3914	6" diameter		9	2.667		595	57.50		652.50	745	
3916	8" diameter	B-21	6	4.667		1,100	103	17.25	1,220.25	1,375	
3918	10" diameter		5	5.600		2,025	124	20.50	2,169.50	2,450	
3920	12" diameter		4	7		2,825	155	26	3,006	3,400	
3922	14" diameter		3	9.333		3,050	206	34.50	3,290.50	3,725	
3924	16" diameter		2	14		4,450	310	52	4,812	5,450	
3926	18" diameter		.80	35		4,900	775	130	5,805	6,750	
3928	20" diameter		.60	46.667		7,300	1,025	173	8,498	9,850	
39	24" diameter		.50	56		8,650	1,250	207	10,107	11,700	
	Piping, site utility, fittings, corporations, brass, 3/4" diameter	1 Plum	19	.421		11.50	11.90		23.40	31	
504	1" diameter		16	.500		18.75	14.15		32.90	42	
5060	1-1/2" diameter		13	.615		52	17.40		69.40	83.50	
5080	2" diameter		11	.727		88.50	20.50		109	129	
5200	Curb stops, brass, 3/4" diameter		19	.421		15.40	11.90		27.30	35	
5220	1" diameter		16	.500		24	14.15		38.15	48	
5240	1-1/2" diameter		13	.615		60	17.40		77.40	92.50	
5260	2" diameter		11	.727		96.50	20.50		117	138	
5400	Curb box, cast iron, 3/4" diameter		12	.667		29	18.85		47.85	61	
5420	2" diameter		8	1		70	28.50		98.50	120	
5500	Saddles, cast iron, 3/4", add					27			27	29.50	
5550	2", add					33.50			33.50	37	

026 450 | Hydrants

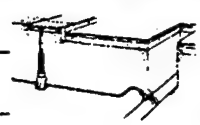


	Description	Crew	Daily Output	Man-Hours	Unit	Mat.	Labor	Equip.	Total	Total Incl. O&P	
0010	PIPING, WATER DISTRIBUTION Mech. joints unless noted										454
1000	Fire hydrants, two way; excavation and backfill not incl.										
1100	4-1/2" valve size, depth 2'-0"	B-21	10	2.800	Ea.	735	62	10.35	807.35	920	
1120	2'-6"		10	2.800		760	62	10.35	832.35	945	
1140	3'-0"		10	2.800		785	62	10.35	857.35	975	
1160	3'-6"		9	3.111		810	69	11.50	890.50	1,025	
1200	4'-6"		9	3.111		835	69	11.50	915.50	1,050	
1220	5'-0"		8	3.500		860	77.50	12.95	950.45	1,075	
1240	5'-6"		8	3.500		915	77.50	12.95	1,005.45	1,125	
1260	6'-0"		7	4		1,000	88.50	14.80	1,103.30	1,250	
1280	6'-6"		7	4		1,050	88.50	14.80	1,153.30	1,300	
1300	7'-0"		6	4.667		1,100	103	17.25	1,220.25	1,400	
	8'-0"		6	4.667		1,175	103	17.25	1,295.25	1,475	
14	10'-0"		5	5.600		1,250	124	20.50	1,394.50	1,600	

SITE WORK 2

026 650 | Water Systems

			CREW	DAILY OUTPUT	MAN-HOURS	UNIT	1994 BARE COSTS MAT.	LABOR	EQUIP.	TOTAL	TOTAL INCL O&P	
662	7180	Curb box, cast iron, 1-1/2" diameter	1 Plum	12	.667	Ea.	50	18.85		68.85	84	662
	7200	2" diameter		8	1		90	28.50		118.50	142	
	7220	Saddles, 3/4" diameter, add					30			30	33	
	7240	2" diameter, add					40			40	44	
	7250	For copper fittings, see Div. 151-430										
666	0010	PIPING, WATER DISTRIBUTION, DUCTILE IRON cement lined										666
	0020	Not including excavation or backfill										
	2000	Pipe, class 50 water piping, 18' lengths										
	2020	Mechanical joint, 4" diameter	B-20	144	.167	L.F.	7.40	3.59		10.99	13.85	
	2040	6" diameter		126	.190		8.45	4.10		12.55	15.80	
	2060	8" diameter	B-21	108	.259		11.15	5.75	.96	17.86	22.50	
	2080	10" diameter		90	.311		14.20	6.90	1.15	22.25	27.50	
	2100	12" diameter		72	.389		18.50	8.60	1.44	28.54	35.50	
	2120	14" diameter		54	.519		23	11.45	1.92	36.37	45.50	
	2140	16" diameter		46	.609		25.50	13.45	2.25	41.20	51.50	
	2160	18" diameter	B-22	38	.789		28.50	17.60	4.09	50.19	63	
	2170	20" diameter		37	.811		32.50	18.10	4.20	54.80	68.50	
	2180	24" diameter		36	.833		45.50	18.60	4.32	68.42	84.50	
	3000	Tyton, Push-on joint, 4" diameter	B-20	158	.152		6.15	3.27		9.42	12	
	3020	6" diameter		138	.174		6.85	3.75		10.60	13.50	
	3040	8" diameter	B-21	118	.237		8.70	5.25	.88	14.83	18.75	
	3060	10" diameter		100	.280		11.50	6.20	1.04	18.74	23.50	
	3080	12" diameter		80	.350		14.65	7.75	1.30	23.70	29.50	
	3100	14" diameter		60	.467		17.95	10.30	1.73	29.98	38	
	3120	16" diameter		54	.519		21	11.45	1.92	34.37	43.50	
	3140	18" diameter	B-22	44	.682		24	15.20	3.53	42.73	54.50	
	3160	20" diameter		42	.714		26.50	15.95	3.70	46.15	58	
	3180	24" diameter		40	.750		32.50	16.75	3.89	53.14	66.50	
	4000	Drill and tap pressurized main (labor only)										
	4100	6" main, 1" to 2" service	Q-1	3	5.333	Ea.		136		136	207	
	4150	8" main, 1" to 2" service		2.75	5.818			148		148	226	
	4500	Tap and insert gate valve										
	4600	8" main, 4" branch	B-21	3.20	8.750	Ea.		193	32.50	225.50	340	
	4650	6" branch		2.70	10.370			229	38.50	267.50	400	
	4651	Piping, drill, tap & insert gate valve, 8" main, 6" branch		2.70	10.370			229	38.50	267.50	400	
	4700	10" main, 4" branch		2.70	10.370			229	38.50	267.50	400	
	4750	6" branch		2.35	11.915			263	44	307	465	
	4800	12" main, 6" branch		2.35	11.915			263	44	307	465	
	4850	8" branch		2.35	11.915			263	44	307	465	
	8000	Fittings										
	8006	Mechanical joint, 90° bend or elbows, 4" diameter	B-20	37	.649	Ea.	90	14		104	121	
	8020	6" diameter		25	.960		121	20.50		141.50	166	
	8040	8" diameter		21	1.143		197	24.50		221.50	256	
	8060	10" diameter	B-21	21	1.333		253	29.50	4.93	287.43	330	
	8080	12" diameter		18	1.556		335	34.50	5.75	375.25	425	
	8100	14" diameter		16	1.750		540	38.50	6.45	584.95	665	
	8120	16" diameter		14	2		610	44	7.40	661.40	750	
	8140	18" diameter		10	2.800		940	62	10.35	1,012.35	1,125	
	8160	20" diameter		8	3.500		1,050	77.50	12.95	1,140.45	1,300	
	8180	24" diameter		6	4.667		1,400	103	17.25	1,520.25	1,700	
	8200	Wye or tee, 4" diameter	B-20	25	.960		131	20.50		151.50	177	
	8220	6" diameter		17	1.412		182	30.50		212.50	248	
	8240	8" diameter		14	1.714		258	37		295	340	
	8260	10" diameter	B-21	14	2		410	44	7.40	461.40	530	
	8280	12" diameter		12	2.333		535	51.50	8.65	595.15	680	

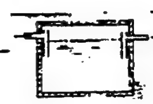


See the Reference Section for reference number information, Crew Listings and City Cost Indexes

026 650 | Water Systems

		CREW	DAILY OUTPUT	MAN-HOURS	UNIT	1994 BARE COSTS MAT.	LABOR	EQUIP.	TOTAL	TOTAL INCL O&P	
8300	14" diameter	B-21	10	2.800	Ea.	655	62	10.35	727.35	830	666
8320	16" diameter		8	3.500		920	77.50	12.95	1,010.45	1,125	
83	18" diameter		6	4.667		1,375	103	17.25	1,495.25	1,675	
836	20" diameter		4	7		1,575	155	26	1,756	2,000	
8380	24" diameter		3	9.333		2,125	206	34.50	2,365.50	2,700	
8400	45° bends, 6" diameter	B-20	24	1		111	21.50		132.50	156	
8410	12" diameter	•	16	1.500		293	32.50		325.50	370	
8420	16" diameter	B-21	12	2.333		505	51.50	8.65	565.15	645	
8430	20" diameter		6	4.667		855	103	17.25	975.25	1,125	
8440	24" diameter		4	7		1,225	155	26	1,406	1,625	
8450	Decreaser, 6" x 4" diameter	B-20	12	2		92	43		135	170	
8460	8" x 6" diameter		10	2.400		143	51.50		194.50	239	
8470	10" x 6" diameter		9	2.667		173	57.50		230.50	282	
8480	12" x 6" diameter		8	3		214	64.50		278.50	340	
8490	6" x 16" diameter	B-21	6	4.667		355	103	17.25	475.25	575	
8500	6" x 20" diameter		5	5.600		565	124	20.50	709.50	845	
8510	6" x 24" diameter		4	7		1,075	155	26	1,256	1,450	
8610	Blind flanges, 150 psi., 4" diameter	Q-1	10	1.600		39	41		80	105	
8620	5" diameter	•	8	2		51	51		102	134	
8630	6" diameter	Q-2	10	2.400		59	63.50		122.50	162	
8640	8" diameter		8	3		97	79.50		176.50	228	
8650	10" diameter		7	3.429		189	90.50		279.50	345	
8660	12" diameter		6	4		281	106		387	470	
8670	14" diameter		5	4.800		430	127		557	665	
8680	16" diameter		5	4.800		480	127		607	720	
8690	18" diameter		4	6		580	159		739	880	
8700	20" diameter		3	8		725	211		936	1,125	
871	24" diameter		2	12		1,100	315		1,415	1,675	
87	250 psi, 4" diameter	Q-1	6	2.667		61	68		129	172	
873	5" diameter	•	4	4		117	102		219	284	
8740	6" diameter	Q-2	6	4		107	106		213	279	
8750	8" diameter		4	6		163	159		322	420	
8760	10" diameter		3.40	7.059		350	186		536	670	
8770	12" diameter		2.80	8.571		470	226		696	860	
8780	14" diameter		2.80	8.571		745	226		971	1,175	
8790	16" diameter		2	12		865	315		1,180	1,450	
8800	18" diameter		2	12		1,175	315		1,490	1,775	
8810	20" diameter		1.50	16		1,325	425		1,750	2,100	
8820	24" diameter		1	24		2,425	635		3,060	3,650	
9020	Slip on weld flanges, 150lbs., 4" diameter	Q-15	6	2.667		31.50	68	8.55	108.05	148	
9030	5" diameter	•	5	3.200		44	81.50	10.25	135.75	184	
9040	6" diameter	Q-16	6	4		51	106	8.50	165.50	226	
9050	8" diameter		5	4.800		78.50	127	10.20	215.70	291	
9060	10" diameter		4	6		143	159	12.80	314.80	415	
9070	12" diameter		3	8		209	211	17.05	437.05	570	
9080	14" diameter		3	8		281	211	17.05	509.05	650	
9090	16" diameter		2	12		340	315	25.50	680.50	890	
9100	18" diameter		2	12		495	315	25.50	835.50	1,050	
9110	20" diameter		1	24		570	635	51	1,256	1,650	
9120	24" diameter		1	24		810	635	51	1,496	1,900	
9130	300 lbs., 4" diameter	Q-15	6	2.667		52	68	8.55	128.55	170	
9140	5" diameter	•	4	4		84.50	102	12.80	199.30	262	
9150	6" diameter	Q-16	6	4		86.50	106	8.50	201	266	
916	8" diameter		4	6		143	159	12.80	314.80	415	
9	10" diameter		3.40	7.059		275	186	15.05	476.05	605	
91	12" diameter		2.80	8.571		340	226	18.25	584.25	740	

027 400 | Septic Systems



	027 400 | Septic Systems	CREW	DAILY OUTPUT	MAN-HOURS	UNIT	1994 BARE COSTS MAT.	LABOR	EQUIP.	TOTAL	TOTAL INCL O&P
404 0060	1,500 gallon	B-21	7	4	Ea.	590	88.50	14.80	693.30	815
0100	2,000 gallon		5	5.600		820	124	20.50	964.50	1,125
0140	2,500 gallon		5	5.600		825	124	20.50	969.50	1,150
0180	4,000 gallon		4	7		2,875	155	26	3,056	3,450
0220	5,000 gal., 4 piece		3	9.333		4,900	206	34.50	5,140.50	5,775
0300	15,000 gallon	B-13	1.30	43.077		9,900	880	380	11,160	12,800
0400	25,000 gallon		.80	70		14,600	1,425	615	16,640	19,200
0500	40,000 gallon		.60	93.333		22,500	1,900	820	25,220	28,900
0600	High density polyethylene, 1,000 gallon	B-21	6	4.667		725	103	17.25	845.25	990
0700	1,500 gallon		4	7		950	155	26	1,131	1,325
0900	Galley, 4' x 4' x 4'		16	1.750		165	38.50	6.45	209.95	254
1000	Distribution boxes, concrete, 7 outlets	2 Clab	16	1		65	19		84	104
1100	9 outlets	•	8	2		210	38		248	295
1150	Leaching field chambers, 13' x 3'-7" x 1'-4", standard	B-13	16	3.500		325	71.50	30.50	427	515
1200	Heavy duty, 8' x 4' x 1'-6"		14	4		225	82	35	342	425
1300	13' x 3'-9" x 1'-6"		12	4.667		375	95.50	41	511.50	620
1350	20' x 4' x 1'-6"		5	11.200		585	229	98.50	912.50	1,125
1600	Leaching pit, 6'-6 diameter, 6' deep	B-21	5	5.600		435	124	20.50	579.50	710
1620	8' deep		4	7		525	155	26	706	865
1700	8' diameter, H-20 load, 6' deep		4	7		725	155	26	906	1,075
1720	8' deep		3	9.333		895	206	34.50	1,135.50	1,375
2000	Velocity reducing pit, precast conc., 6' diameter, 3' deep		4.70	5.957		215	132	22	369	480
2200	Excavation for septic tank, 3/4 C.Y. backhoe	B-12F	145	.110	C.Y.		2.55	2.98	5.53	7.35
2400	4' trench for disposal field, 3/4 C.Y. backhoe	•	335	.048	L.F.		1.10	1.29	2.39	3.19
2600	Gravel fill, run of bank	B-6	150	.160	C.Y.	9.50	3.28	1.33	14.11	17.30
2800	Crushed stone, 3/4"	•	150	.160	•	15	3.28	1.33	19.61	23.50

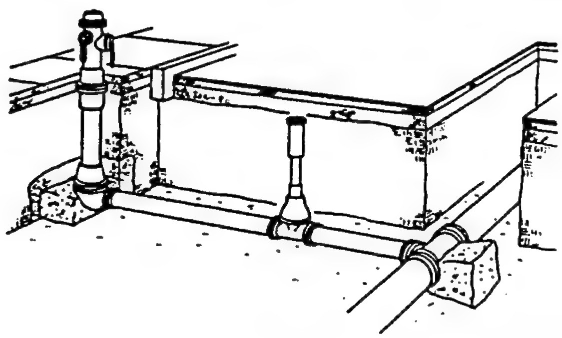
027 660 | Relining Exist. Pipelines

	027 660 | Relining Exist. Pipelines	CREW	DAILY OUTPUT	MAN-HOURS	UNIT	MAT.	LABOR	EQUIP.	TOTAL	TOTAL INCL O&P
664 0010	LINING PIPE with cement, incl. bypass and cleaning									
0020	Less than 10,000 L.F., urban, 6" to 10"	C-17E	130	.615	L.F.	5.65	15.40	.45	21.50	32
0050	10" to 12"		125	.640		6.95	16.05	.47	23.47	34.50
0070	12" to 16"		115	.696		7.15	17.45	.51	25.11	37.50
0100	16" to 20"		95	.842		8.35	21	.61	29.96	45
0200	24" to 36"		90	.889		9	22.50	.65	32.15	47.50
0300	48" to 72"		80	1		14.35	25	.73	40.08	58.50
0500	Rural, 6" to 10"		180	.444		5.65	11.15	.32	17.12	25
0550	10" to 12"		175	.457		6.95	11.45	.33	18.73	27
0570	12" to 16"		160	.500		7.25	12.50	.36	20.11	29.50
0600	16" to 20"		135	.593		7.65	14.85	.43	22.93	34
0700	24" to 36"		125	.640		9.15	16.05	.47	25.67	37
0800	48" to 72"		100	.800		14.35	20	.58	34.93	50
1000	Greater than 10,000 L.F., urban, 6" to 10"		160	.500		5.65	12.50	.36	18.51	27.50
1050	10" to 12"		155	.516		6.85	12.95	.38	20.18	29.50
1070	12" to 16"		140	.571		7.15	14.30	.42	21.87	32.50
1100	16" to 20"		120	.667		7.65	16.70	.49	24.84	37
1200	24" to 36"		115	.696		9.15	17.45	.51	27.11	39.50
1300	48" to 72"		95	.842		14.35	21	.61	35.96	51.50
1500	Rural, 6" to 10"		215	.372		5.65	9.30	.27	15.22	22
1550	10" to 12"		210	.381		6.95	9.55	.28	16.78	24
1570	12" to 16"		185	.432		7.15	10.85	.32	18.32	26.50
1600	16" to 20"		150	.533		7.65	13.35	.39	21.39	31.50
1700	24" to 36"		140	.571		9.15	14.30	.42	23.87	34.50
1800	48" to 72"		120	.667		14.45	16.70	.49	31.64	44.50

050 500 | Metal Fastening

			CREW	DAILY OUTPUT	MAN-HOURS	UNIT	1994 BARE COSTS MAT.	LABOR	EQUIP.	TOTAL	TOTAL INCL O&P	
	8250	1/2" diameter, 2-3/4" long	1 Carp	140	.057	Ea.	.91	1.36		2.27	3.15	520
	8300	7" long		130	.062		1.58	1.46		3.04	4.06	
	8550	1" diameter, 6" long		100	.080		7.70	1.90		9.60	11.45	
	8600	12" long		80	.100		10.75	2.38		13.13	15.55	
	8750	For type 303 stainless steel, add					350%					
	8800	For type 316 stainless steel, add					450%					
530	0010	LAG SCREWS Steel, 1/4" diameter, 2" long	1 Carp	140	.057	Ea.	.05	1.36		1.41	2.21	530
	0100	3/8" diameter, 3" long		105	.076		.13	1.81		1.94	3.01	
	0200	1/2" diameter, 3" long		95	.084		.24	2		2.24	3.43	
	0300	5/8" diameter, 3" long		85	.094		.39	2.24		2.63	3.98	
535	0010	MACHINE SCREWS Steel, #8 x 1" long, round head				C	.93			.93	1.02	535
	0110	#8 x 2" long					1.84			1.84	2.02	
	0200	#10 x 1" long					1.12			1.12	1.23	
	0300	#10 x 2" long					1.89			1.89	2.08	
540	0010	MACHINERY ANCHORS Standard, flush mounted,										540
	0020	incl. stud w/fiber plug, nut & washer, anchor & anchor bolt										
	0200	Material only, 1/2" diameter stud & bolt				Ea.	20.50			20.50	22.50	
	0300	5/8" diameter					23			23	25	
	0500	3/4" diameter					25			25	27.50	
	0600	7/8" diameter					29			29	31.50	
	0800	1" diameter					32			32	35	
	0900	1-1/4" diameter					40.50			40.50	44.50	
550	0010	STUDS .22 caliber stud driver, minimum				Ea.	225			225	248	550
	0100	Maximum				•	385			385	425	
	0300	Powder charges for above, low velocity				C	20			20	22	
	0400	Standard velocity				•	22			22	24	
555	0010	TRACK Railroad, bolts				Cwt.	105			105	116	555
	0100	Joint bars				Pr.	16			16	17.60	
	0200	Spikes				Cwt.	38			38	42	
	0300	Tie plates				Ea.	12			12	13.20	
570	0010	WELD ROD Steel, type E6010/E6011, 1/8" diameter, less than 500#				Lb.	.91			.91	1	570
	0100	500# to 2,000#				•	.86			.86	.95	
	0200	2,000# to 5,000#				Lb.	.80			.80	.88	
	0400	Steel, type E6011, 3/16" diameter, less than 500#					.88			.88	.97	
	0500	500# to 2,000#					.81			.81	.89	
	0600	2000# to 5000#					.76			.76	.84	
	0650	Steel, type E7018, (low hydrogen) 1/8" diam., less than 500#					.83			.83	.91	
	0660	500# to 2000#					.79			.79	.87	
	0670	2,000# to 5,000#					.74			.74	.81	
	0700	Steel, type E7024, (jet weld) 1/8" diam., less than 500#					.86			.86	.95	
	0710	500# to 2,000#					.79			.79	.87	
	0720	2,000# to 5,000#					.76			.76	.84	
	0800	Deduct for 5/32" diameter, type E6010 or type E6011					.02			.02	.02	
	0810	Semi-automatic coils, 1/16" diameter, 3000# lots					.76			.76	.84	
	1550	Aluminum, type 4043, 1/8" diameter					3.75			3.75	4.13	
	1600	5/32" diameter, 50-100#					3.65			3.65	4.02	
	1810	3/16" diameter, 100-500#					3.55			3.55	3.91	
	1900	Cast iron, 1/8" diameter					2.20			2.20	2.42	
	2000	Stainless steel, type 308-15, 1/8" diam., less than 499#					4.70			4.70	5.15	
	2100	500# to 999#					4.40			4.40	4.84	
	2220	Over 1000#					3.60			3.60	3.96	
575	0010	WELDING Field. Cost per welder, no operating engineer R050-520	E-14	8	1	Hr.	2.73	28.50	9.45	40.68	66	575
	0200	With 1/2 operating engineer	E-13	8	1.500		2.73	40	9.45	52.18	84	
	0300	With 1 operating engineer	E-12	8	2		2.73	52	9.45	64.18	101	
	0500	With no operating engineer, minimum	E-14	13.30	.602	Ton	1.82	17.15	5.70	24.67	40	

5 METALS



The Fire Hydrant Systems include: four different hydrants with three different lengths of offsets, at several depths of trenching. Excavation and backfill is included with each system as well as thrust blocks as necessary and pipe bedding. Finally spreading of excess material and fine grading complete the components.

System Components	QUANTITY	UNIT	COST PER EACH MAT.	INST.	TOTAL
SYSTEM 12.3-922-1500					
HYDRANT, 4-1/2" VALVE SIZE, TWO WAY, 10' OFFSET, 2' DEEP					
Excavation, trench, 1 C.Y. hydraulic backhoe	3.556	C.Y.		16.46	16.46
Sleeve, 12" x 6"	1.000	Ea.	1,100	60.35	1,160.35
Offset pipe, 6", CL, 250, ductile iron	8.000	L.F.	73.60	52	125.60
Gate valve, 6"	1.000	Ea.	495	54.70	549.70
Gate box	1.000	Ea.	90	41	131
Hydrant, incl. lower barrel and shoe	1.000	Ea.	810	108.90	918.90
Thrust blocks, at valve, shoe and sleeve	1.600	C.Y.	130.40	176.16	306.56
Compacted backfill and drainage stone	4.089	C.Y.	67	46.99	113.99
Spread excess excavated material	.204	C.Y.		4.49	4.49
Fine grade, hand	400.000	S.F.		140	140
TOTAL			2,766	701.05	3,467.05

12.3-922	Fire Hydrants	COST PER EACH MAT.	INST.	TOTAL
1000	Hydrant, 4-1/2" valve size, two way, 0' offset, 2' deep	2,700	460	3,160
1100	4' deep	2,775	460	3,235
1200	6' deep	2,975	505	3,480
1300	8' deep	3,200	540	3,740
1400	10' deep	3,275	570	3,845
1500	10' offset, 2' deep	2,775	705	3,480
1600	4' deep	2,850	825	3,675
1700	6' deep	3,050	1,100	4,150
1800	8' deep	3,275	1,475	4,750
1900	10' deep	3,350	2,275	5,625
2000	20' offset, 2' deep	2,850	950	3,800
2100	4' deep	2,950	1,150	4,100
2200	6' deep	3,150	1,550	4,700
2300	8' deep	3,350	2,100	5,450
2400	10' deep	3,425	2,850	6,275
2500	Hydrant, 4-1/2" valve size, three way, 0' offset, 2' deep	2,750	465	3,215
2600	4' deep	2,825	465	3,290
2700	6' deep	3,050	515	3,565
2800	8' deep	3,275	550	3,825
2900	10' deep	3,375	590	3,965
3000	10' offset, 2' deep	2,825	710	3,535
3100	4' deep	2,900	835	3,735
3200	6' deep	3,125	1,100	4,225
3300	8' deep	3,350	1,475	4,825
3400	10' deep	3,450	2,275	5,725
3500	20' offset, 2' deep	2,925	955	3,880
3600	4' deep	3,000	1,175	4,175
3700	6' deep	3,225	1,575	4,800

See the Reference Section for reference number information, Crew Listings and City Cost Indexes

APPENDIX E

PROGRAMMING DOCUMENTATION

ECO #1 - Implement Leak Detection Program
ECO #2 - Reline Sections of Process Water Piping
ECO #3 - Isolate Piping in Caretaker Areas
ECO #4 - Implement Leak Detection Program (After ECOs #2 and #3)

1. COMPONENT ARMY	FY 1995 MILITARY CONSTRUCTION PROJECT DATA	2. DATE May-95

3. INSTALLATION AND LOCATION	4. PROJECT TITLE
Badger Army Ammunition Plant; Baraboo, WI	Implement Leak Detection Program

5. PROGRAM ELEMENT	6. CATEGORY CODE	7. PROJECT NUMBER	8. PROJECT COST ($000)

9. COST ESTIMATES

ITEM	U/M	QUANTITY	UNIT COST	COST
ECIP: Implement Water Audit & Leak Detection Program	LS			$18,000
TOTAL CONTRACT COST				18,000
SIOH (6%)				1,080
DESIGN COST (6%)				1,080
TOTAL PROJECT COST				20,160
TOTAL REQUEST (ROUNDED)				21,000

10. DESCRIPTION OF PROPOSED CONSTRUCTION

Implement a water audit and leak detection program for approximately 120 miles of process water system at the Badger Army Ammunition Plant (BAAP).

11. REQUIREMENT:

Project: This Energy Conservation Investment Program (ECIP) project will implement a water audit and leak detection program for the process water system at BAAP.

Requirement: This project is required to reduce process water usage at BAAP. A reduction of leakage in the process water system would result in immediate energy and maintenance savings.

Current Situation: Currently, BAAP pumps approximately 250,900,000 gallons of water per year into the process water system. A water audit has revealed that, of this amount, about 116,734,000 gallons of water (46%) is in the form of leakage that can be recovered. It is BAAP's policy that leakage that is discovered in a leak detection survey will be immediately excavated and repaired.

Impact If Not Provided: Failure to implement this project will cause BAAP to not realize a $40,740 annual savings with a 0.49 year simple payback and a savings-to-investment ratio of 30.34.

Supporting Documentation: Supporting data for basic engineering calculations which show energy savings and cost savings are documented in a report under COE Contract No. DACA01-94-D-0033, performed by an A/E firm in FY95.

Verification of Savings: Process water system pumps have existing meters which display the amount of water pumped to the process water system. These meters are read on a monthly basis. Historic data was obtained for the period of January 1992 through September 1994 as a basis for the report mentioned above. The amount of water pumped for the period subsequent to the ECIP project implementation can be used to compare the quantity of water pumped after the ECIP project is implemented. Assuming that the process water demand has remained fairly constant, the amount of water saved in repairing the leakage should be the difference.

Amount of Water Conserved: The amount of water conserved is estimated to be 116,734,000 gallons per year.

1. COMPONENT ARMY	FY 1995 MILITARY CONSTRUCTION PROJECT DATA	2. DATE May-95
3. INSTALLATION AND LOCATION Badger Army Ammunition Plant; Baraboo, WI		
4. PROJECT TITLE Implement Leak Detection Program		5. PROJECT NUMBER

ECONOMIC ANALYSIS

A water audit was performed on the process water system at BAAP according to the guidelines set by American Water Works Association (AWWA) Manual 36, entitled "Water Audits and Leak Detection". The audit was based on information supplied by BAAP personnel. Water usage in the process water system can be separated into the following categories:

- **Fire Protection**. Each fire hydrant is exercised for approximately 10 minutes each summer. There are approximately 675 hydrants at BAAP.
- **Industrial Uses**. Process water is used for steam production and as a once-through cooling system at the Powerhouse, for some domestic uses, and for maintenance activities such as tank cleaning.
- **Irrigation Water for Cattle**. In the summer months, water is taken from a hydrant and used to supply water to cattle.
- **Discovered Leaks**. BAAP has a team of maintenance personnel that repair leakage in the process water system that is large enough to be discovered without the aid of a leak detection survey. Approximately 63 leaks were repaired last year, approximately 80% located on main pipelines.
- **Reservoir Evaporation**. The process water system uses an open reservoir for storage. The amount of water that evaporates off the surface of the reservoir was calculated using pan evaporation data from NOAA Technical Report NWS 33 and 34.

The results of the water audit are given on page 5. The amount of recoverable leakage, which is estimated as 75% of the potential water system leakage, was calculated to be 116,734,000 gallons per year. This value represents approximately 46% of the total amount of water pumped from various process water sources; 250,900,000 gallons per year. This figure was obtained from BAAP historical meter data from 1992 to 1994.

The total beneficial value of repairing recoverable leakage was calculated. Beneficial value is calculated by multiplying the amount of leakage saved times the cost of process water. The cost of process water at BAAP is a combination of several factors:

- **Pump Electrical Consumption**. Process water will be pumped into the distribution system primarily by a 500 gpm pump with a 40 hp motor. The pump is located at the Pump & Treat (IRM) Facility. Well No. 4, with a capacity of 935 gpm and a 100 hp motor, supplements the IRM Facility pump during periods of peak demand and maintenance. A reduction of leakage in the process water distribution system would reduce the amount of water that is pumped, thus saving electrical energy consumed by the pumps.
- **Chemical Treatment**. Chlorine is currently fed into the process water system at the source. High quality, bacteria-free water is required for production and domestic uses. Because chlorine is injected per volume of process water pumped, reducing the amount of leakage lost would reduce the amount of chlorine required.

1. COMPONENT ARMY	FY 1995 MILITARY CONSTRUCTION PROJECT DATA	2. DATE May-95
3. INSTALLATION AND LOCATION Badger Army Ammunition Plant; Baraboo, WI		
4. PROJECT TITLE Implement Leak Detection Program	5. PROJECT NUMBER	

ECONOMIC ANALYSIS (cont.)

- **Well Maintenance.** Money is annually budgeted to maintain the five wells at BAAP. Two of the wells (No. 4 & 5) are used as sources for the process water system. Decreased operating time for the well pumps will reduce the amount of maintenance required for pumps and pump motors.
- **Distribution Maintenance.** BAAP uses a maintenance crew to repair leakage in the distribution system. If leakage can be reduced in the distribution system, fewer labor hours will be needed to located and repair leakage.

The total beneficial cost of performing a leak detection survey to recover leakage from the process water system was assumed to be only the costs that vary with the amount of water delivered. These include the energy, well maintenance and chemical treatment costs. Distribution maintenance costs were not included because they are budgeted, fixed costs. The cost of leak repair is also not included. Since leaks are continually discovered and repaired in the normal course of operations, the leaks found in the leak detection program would be repaired eventually. If the leaks are repaired as part of a leak detection program, as is BAAP's policy, BAAP avoids the expense of repairing leaks as they are accidentally discovered. Although some cost savings would be realized in fixing the leaks when they are discovered by a leak detection program, as opposed to discovering them accidentally, AWWA Manual 36 allows the auditor to assume that the savings is negligible.

The total payback of the leak detection program was calculated by dividing the total cost of the leak detection program by the cost savings of recovering leakage. The total cost of the leak detection survey was taken from the average cost of previous leak detection surveys at BAAP and from cost information provided by AWWA. The cost of leak detection was given as $150 per mile of pipe surveyed. There is an estimated 120 miles of pipe in the process water system at BAAP.

A summary of the water audit, along with the LCCA, is provided on the following pages.

1. COMPONENT ARMY	FY 1995 MILITARY CONSTRUCTION PROJECT DATA	2. DATE May-95
3. INSTALLATION AND LOCATION Badger Army Ammunition Plant; Baraboo, WI		
4. PROJECT TITLE BAAP Water Conservation Study		5. PROJECT NUMBER

LIFE CYCLE COST ANALYSIS SUMMARY
ENERGY CONSERVATION INVESTMENT PROGRAM (ECIP)

LOCATION:	Badger Army Ammunition Plant	REGION: 2 (Wisconsin)		PROJECT NO:	1406-004
PROJECT TITLE:	Leak Detection Study			FISCAL YEAR:	1995
ANALYSIS DATE:	05/09/95	ECONOMIC LIFE:	20	PREPARED BY:	T. Poeling

1. INVESTMENT: **ECO #1 - Implement Leak Detection Program**

A. CONSTRUCTION COST		=	$18,000	
B. SIOH COST	(6.0% of 1A)	=	$1,080	
C. DESIGN COST	(6.0% of 1A)	=	$1,080	
D. TOTAL COST	(1A +1B +1C)	=	$20,160	
E. SALVAGE VALUE OF EXISTING EQUIPMENT =			$0	
F. PUBLIC UTILITY COMPANY REBATE =			$0	
G. TOTAL INVESTMENT	(1D -1E -1F)	=	------->	$20,160

2. ENERGY SAVINGS (+) OR COST (-):

DATE OF NISTR 4942-1 USED FOR DISCOUNT FACTORS: BOD Oct 1994

ENERGY SOURCE	FUEL COST $/KGAL (1)	SAVINGS KGAL/YR (2)	ANNUAL $ SAVINGS (3)	DISCOUNT FACTOR (4)	DISCOUNTED SAVINGS (5)	
A. ELECT. (CURRENT)	$0.05	116,734	$5,486	15.88	$87,125	
B. ELECT. (POTENTIAL)	$0.05	0	$0	15.88	$0	
C. DIST	$5.00	0	$0	19.16	$0	
D. NAT GAS	$4.00	0	$0	18.30	$0	
E. COAL	$2.60	0	$0	16.62	$0	
G. DEMAND (KW)	$6.82	0	$0	14.88	$0	
H. TOTAL		116,734	$5,486		-------->	$87,125

3. NON-ENERGY SAVINGS (+) OR COST (-)

A. ANNUAL RECURRING (+/-)

1 WELL MAINTENANCE ($0.27/KGAL)	$31,518	14.88	$468,990
2 WATER DIST. MAINTENANCE ($1.22/KGAL)	$0	14.88	$0
3 CHEMICAL TREAT. SAVINGS ($0.032/KGAL)	$3,735	14.88	$55,584
4 TOTAL ANNUAL DISC. SAVINGS (+) / COST (-)	$35,254		$524,574

B. NON-RECURRING (+/-)

ITEM	SAVINGS (+) COST(-) (1)	YEAR OF OCCURRENCE (2)	DISCOUNT FACTOR (3) (TABLE A-2)	DISCOUNTED SAVINGS/ COST (4)
a.	$0		0.000	$0
b.	$0		0.000	$0
c.	$0		0.000	$0
d. TOTAL	$0			$0

C. TOTAL NON-ENERGY DISCOUNTED SAVINGS (+) OR COST (-)	(3A4 + 3Bd4) =	$524,574
4. FIRST YEAR DOLLAR SAVINGS (+) / COSTS (-)	(2H3+3A+(3Bd1/Economic Life))	$40,740
5. SIMPLE PAYBACK (SPB) IN YEARS (MUST BE < 10 YEARS TO QUALIFY)	(1G/4) =	0.49
6. TOTAL NET DISCOUNTED SAVINGS	(2H5 + 3C) =	$611,699
7. DISCOUNTED SAVINGS-TO-INVESTMENT RATIO (SIR) (MUST HAVE SIR > 1.25 TO QUALIFY)	(6/1G) =	30.34

1. COMPONENT ARMY	FY 1995 MILITARY CONSTRUCTION PROJECT DATA	2. DATE May-95
3. INSTALLATION AND LOCATION Badger Army Ammunition Plant; Baraboo, WI		
4. PROJECT TITLE BAAP Water Conservation Study	5. PROJECT NUMBER	

WATER AUDIT

Total Amount of Water Pumped (metered):		250,900,000
Unmetered Water Uses (Provided by BAAP):		
Fire hydrant exercising:	2000 gpm x 10 min x 675 hydrants	13,500,000
Industrial uses:		
Boilers	32,000,000 lbs/yr x 1,198 gals/lb	3,900,000
Cooling Water	40 gpm x 1,440 min/day x 365 days/yr	21,100,000
Domestic Water	525,000 gals/month x 12 months/yr	6,300,000
Maintenance Activities	20 gpm x 60 min/hr x 10 hrs/day x 4 days/wk x 52 weeks/year	2,500,000
Irrigation (Cattle)	400,000 gals/month x 6 months	2,400,000
Discovered Leaks (by maintenance personnel, not leak detection survey):		
Main water breaks	50 breaks x 20 gpm x 1,440 min/day x 30 days	43,200,000
Service laterals & valves	13 breaks x 2 gpm x 1,440 min/day x 30 days	1,123,200
Reservoir Evaporation (calculated value)		1,231,700
Total Identified Water Losses:		**95,254,900**
Potential Water System Leakage:		**155,645,100**
Recoverable Leakage (AWWA Manual 36 estimates 75% is recoverable):		**116,733,825**
Cost of Water Supply (per 1000 gallons):	$0.05 pumping costs, $0.032 chemical treatment	**$0.349**
One Year Benefit from Recoverable Leakage:		**$40,740**
Total Cost of Leak Detection Program:	$150 / mile x 120 miles	**$20,160**
Benefit to Cost Ratio:		**2.02**
Simple Payback (years):		**0.5**

WATER AUDIT WORKSHEET

For: Badger Army Ammunition Plant Audit Study Period: Avg. Year (1992-1994)

Line	Item	Water Volume Subtotal	Total Cumulative	Units*
Task 1—Measure Supply				
1	Uncorrected total water supply to the distribution system (total of master meters)		250,900,000	gal/yr.
2A-C	Adjustments to total water supply			
2A	Source meter error (+ or −)	–		
2B	Change in reservoir and tank storage (+ or −)	–		
2C	Other contributions or losses (+ or −)	–		
3	Total adjustments to total water supply (add lines 2A, 2B, and 2C)	–		
4	Adjusted total water supply to the distribution system (add line 1 and line 3)		250,900,000	gal/yr.
Task 2—Measure Metered Use				
5	Uncorrected total metered water use	–		
6	Adjustments due to meter reading lag time (+ or −)	–		
7	Metered deliveries (add lines 5 and 6)	–		
8A-C	Total sales meter error and system-service meter errors (+ or −)			
8A	Residential meter error	–		
8B	Large meter error	–		
8C	Total (add line 8A and 8B)	–		
9	Corrected total metered water deliveries (add lines 7 and 8C)	–		
10	Corrected total unmetered water (subtract line 9 from line 4)		250,900,000	gal/yr.
11A-M	Authorized unmetered water uses			
11A	Firefighting and firefighting training	13,500,000		gal/yr.
11B	Main flushing	–		

NOTE: 1 ac-ft = 43,560 ft^3 = 325,851 gal.

*Units of measure must be consistent throughout the worksheet. The particular unit used (that is, acre-feet, millions of gallons, cubic feet, cubic metres, or other unit) is left to the user.

Form continues on next page.

Line	Item	Water Volume: Subtotal	Water Volume: Total Cumulative	Water Volume: Units*
11A-M	Authorized unmetered water uses (continued)			
11C	Storm drain flushing	–		
11D	Sewer cleaning	–		
11E	Street cleaning	–		
11F	Schools	–		
11G	Landscaping in large public areas:			
	Parks	–		
	Golf courses	–		
	Cemeteries	–		
	Playgrounds	–		
	Highway median strips	–		
	Other landscaping	–		
11H	Decorative water facilities	–		
11I	Swimming pools	–		
11J	Construction sites	–		
11K	Water quality and other testing (pressure testing pipe, water quality, etc.)	–		
11L	Process water ~~at treatment plants~~ industrial uses	33,800,000		gal/yr.
11M	Other unmetered uses (irrigation)	2,400,000		gal/yr.
12	Total authorized unmetered water (add lines 11A through 11M)		49,700,000	gal/yr.
13	Total water losses (subtract line 12 from line 10)		201,200,000	gal/yr.
14A-H	Identified water losses			
14A	Accounting procedure errors	–		
14B	Illegal connections	–		
14C	Malfunctioning distribution system controls	–		
14D	Reservoir seepage and leakage	–		
14E	Evaporation	1,231,700		gal/yr.

NOTE: 1 ac-ft = 43,560 ft^3 = 325,851 gal.

*Units of measure must be consistent throughout the worksheet. The particular unit used (that is, acre-feet, millions of gallons, cubic feet, cubic metres, or other unit) is left to the user.

Form continues on next page.

Line	Item	Water Volume: Subtotal	Water Volume: Total Cumulative	Water Volume: Units*
14A-H	Identified water losses (continued)			
14F	Reservoir overflow	–		
14G	Discovered leaks	44,323,200		gal/yr.
14H	Theft			
15	Total identified water losses (add lines 14A through 14H)	45,554,406		gal/yr.
16	Potential water system leakage (subtract line 15 from line 13)		155,645,106	gal/yr.
17	Recoverable leakage (multiply line 16 by 0.75)		116,733,825	gal/yr.

Line	Item	Dollars per Unit of Volume
18A-B	Cost savings	
18A	Cost of water supply	$0.047/1000 gal
18B	Variable operation and maintenance costs	$0.302/1000 gal
19	Total costs per unit of recoverable leakage (add line 18A and line 18B)	$0.349/1000 gal

Line	Item	Dollars per Year
20	One-year benefit from recoverable leakage (multiply line 17 by line 19)	$40,740
21	Total benefits from recovered leakage (multiply line 20 by 2)	$81,480
22	Total costs of leak detection project	$20,160
23	Benefit to cost ratio (divide line 21 by line 22)	4.04

Prepared by:

Name Tom Roeling

Title EMC Engineers, Inc.

Date 4/20/95

NOTE: 1 ac-ft = 43,560 ft^3 = 325,851 gal.

*Units of measure must be consistent throughout the worksheet. The particular unit used (that is, acre-feet, millions of gallons, cubic feet, cubic metres, or other unit) is left to the user.

FACSIMILE TRANSMITTAL

Olin
ORDNANCE

BADGER ARMY AMMUNITION PLANT

BARABOO, WISCONSIN
FAX: (608) 643-2674
TEL: (608) 643-3361

TO: Tom Poeling DATE: 20 April 1995

COMPANY: EMC Engineers

FACSIMILE PHONE NO: (303) 985-2527

FROM: Randy Sprecher

SUBJECT: Water Usage Data

ADDITIONAL INFORMATION: Attached is estimated annual water usage and water main repairs - as per your request.

Map showing mains to be given highest priority for relining will be mailed.

Concur with Confirmation Notices 2 & 3. No additional comments.

Thanks,

Randy Sprecher

WE ARE TRANSMITTING 1 PAGES IN ADDITION TO THIS COVER SHEET

Water Usage Data

1) Agricultural Usage - Grazing & Irrigation

Use 400,000 gals/mo x 6 mos = 2,400,000 gals/yr.

2) Hydrant Flushing

675 hydrants x 2,000 gpm x 10 min. = 13,500,000 gals/yr.

3) Process Water

a) Boilers 32,000,000 lbs/yr x 1,198 gals/lb = 3,900,000 gals/yr.

b) Cooling Wtr. 40 gpm x 60 min/hr x 24 hr/day x 365 days/yr. = 21,100,000 gals/yr.

c) Domestic Wtr. 525,000 gals/mo x 12 mos/yr = 6,300,000 gals/yr.

d) Maintenance Activities

20 gpm x 60 min/hr x 10 hrs/day x 4 days/wk x 52 wks/yr. = 2,500,000

e) Total = 33,800,00 gals/yr.

4) Leakage

63 water breaks repaired each year. 80% of these are on mains - remainder on service laterials and valves.

1. COMPONENT ARMY	FY 1995 MILITARY CONSTRUCTION PROJECT DATA	2. DATE May-95

3. INSTALLATION AND LOCATION Badger Army Ammunition Plant; Baraboo, WI	4. PROJECT TITLE Clean & Reline Process Water Piping

5. PROGRAM ELEMENT	6. CATEGORY CODE	7. PROJECT NUMBER	8. PROJECT COST ($000)

9. COST ESTIMATES

ITEM	U/M	QUANTITY	UNIT COST	COST
ECIP: Clean & Reline Sections of Process Water Piping	LS			$647,032
TOTAL CONTRACT COST				647,032
SIOH (6%)				38,822
DESIGN COST (6%)				38,822
TOTAL PROJECT COST				724,676
TOTAL REQUEST (ROUNDED)				725,000

10. DESCRIPTION OF PROPOSED CONSTRUCTION

Clean and reline with cement four sections of process water piping at the Badger Army Ammunition Plant (BAAP). The grand total length of pipe to be rehabilitated is 4,890 feet of 24" diameter steel pipe and 5,310 feet of 14" diameter steel pipe.

11. REQUIREMENT:

Project: This Energy Conservation Investment Program (ECIP) project will rehabilitate four specific sections of the process water system at BAAP. A total of 10,200 feet of 14" and 24" diameter steel pipe will be cleaned and relined with cement.

Requirement: This project is required to reduce process water usage at BAAP. A reduction of leakage in the process water system would result in immediate energy and maintenance savings.

Current Situation: Currently, BAAP pumps approximately 250,900,000 gallons of water per year into the process water system. A water audit has revealed that, of this amount, about 116,734,000 gallons of water (46%) is in the form of leakage that can be recovered. A recent leak detection survey revealed that approximately 51,100,000 gallons per year are lost through leakage in these four pipes. BAAP has designated these pipes as being in historically poor condition.

Impact If Not Provided: Failure to implement this project will cause BAAP to not realize a $85,724 annual savings with a 8.45 year simple payback and a savings-to-investment ratio of 1.76.

Supporting Documentation: Supporting data for basic engineering calculations which show energy and maintenance cost savings are documented in a report under COE Contract No. DACA01-94-D-0033, performed by an A/E firm in FY95.

Verification of Savings: Process water system pumps have existing meters which display the amount of water pumped to the process water system. These meters are read on a monthly basis. Historic data was obtained for the period of January 1992 through September 1994 as a basis for the report mentioned above. The amount of water pumped for the period subsequent to the ECIP project implementation can be used to compare the quantity of water pumped after the ECIP project is implemented. Assuming that the process water demand has remained fairly constant, the amount of water saved in repairing the leakage should be the difference.

Amount of Water Conserved: The amount of water conserved is estimated to be 54,600,000 gallons per year.

1. COMPONENT ARMY	FY 1995 MILITARY CONSTRUCTION PROJECT DATA	2. DATE May-95

3. INSTALLATION AND LOCATION
Badger Army Ammunition Plant; Baraboo, WI

4. PROJECT TITLE	5. PROJECT NUMBER
Clean and Reline with Cement Sections of Process Water Piping	

ECONOMIC ANALYSIS

Process water is distributed throughout BAAP by a multi-looped system comprised of approximately 120 miles of piping. The piping network, which is primarily comprised of steel and cast iron mains, was constructed in the 1940's.

BAAP personnel have identified three sections of piping that are in especially poor condition and have been repaired on numerous occasions. The specific sections of piping identified were:

- 24" diameter pipe that runs along coordinate East 3,013. This section starts at Valve #281 to the north and ends at Valve #F-11 to the south. The pipe has a total length of 2,244 feet and supplies 12 branches.
- 24" diameter pipe that runs along coordinate East 2,023. This section starts at Valve #368 to the north and ends at Valve #F-9 to the south. The pipe has a total length of 2,644 feet and supplies 10 branches.
- 14" diameter pipe that runs along coordinate East 4,885. The section starts at Valve #268 to the north and ends at Valve #341 to the south. The pipe has a total length of 2,870 feet and supplies 38 branches.
- 14" diameter pipe that runs along coordinate East 4,215. The section starts at Valve #204 to the north and ends at Valve #242 to the south. The pipe has a total length of 2,440 feet and supplies 22 branches.
- The total length of pipe to be rehabilitated is 4,890 feet of 24" diameter steel pipe and 5,310 feet of 14" diameter steel pipe.

(Note that the coordinate system used to specify water main locations is based on BAAP water maps.)

Patching the leaks on these pipes is merely a temporary solution. Historical process water meter data reveals that the amount of leakage has remained fairly constant over the last 10 years. This would show that new leaks have appeared as old leaks are repaired. Rehabilitation of these pipes would significantly reduce future leakage in the pipes as well as repair any current leakage. By stopping future leakage, future maintenance costs would reduced along with pumping costs. The value of the water lost to leakage is based on several factors:

- **Pump Electrical Consumption**. Process water will be pumped into the distribution system primarily by a 500 gpm pump with a 40 hp motor. The pump is located at the Pump & Treat (IRM) Facility. Well No. 4, with a capacity of 935 gpm and a 100 hp motor, supplements the IRM Facility pump during periods of peak demand and maintenance. A reduction of leakage in the process water distribution system would reduce the amount of water that is pumped, thus saving electrical energy consumed by the pumps.
- **Chemical Treatment**. Chlorine is currently fed into the process water system at the source. High quality, bacteria-free water is required for production and domestic uses. Because chlorine is injected per volume of process water pumped, reducing the amount of leakage lost would reduce the amount of chlorine required.

1. COMPONENT ARMY	FY 1995 MILITARY CONSTRUCTION PROJECT DATA	2. DATE May-95
3. INSTALLATION AND LOCATION Badger Army Ammunition Plant; Baraboo, WI		
4. PROJECT TITLE Clean and Reline with Cement Sections of Process Water Piping		5. PROJECT NUMBER

ECONOMIC ANALYSIS (cont.)

- **Well Maintenance.** Money is annually budgeted to maintain the five wells at BAAP. Two of the wells (No. 4 & 5) are used as sources for the process water system. Decreased operating time for the well pumps will reduce the amount of maintenance required for pumps and pump motors.
- **Distribution Maintenance.** BAAP uses a maintenance crew to repair leakage in the distribution system. If leakage can be reduced in the distribution system, fewer labor hours will be needed to located and repair leakage.

A leak detection survey was performed in October 1994 to locate and quantify current leakage in the process water system. Four major leaks were found on these four sections of pipe. The total amount of water currently lost to leakage was estimated at 51,100,000 gallons per year (140,000 gpd).

Potential leakage in these pipes was predicted using a leakage density factor. The leakage density factor was calculated using the total amount of recoverable leakage in the entire process water system and dividing by the total length of pipe for each diameter. The validity of the leakage density factor is based on the assumption that the process water system is constructed with the same percentage of material throughout, is approximately the same age, is installed in soil with similar characteristics, and is located under land that is used for essentially the same industrial purposes. Multiplying the total length of 14" and 24" diameter piping involved in this project by the leakage density factor of 0.046 gpd per linear foot per diameter of piping, the value for future leakage was estimated to be 3,536,000 gallons per year.

A cost estimate was created to determine the cost of relining the designated amount of piping. The cost for relining pipe per linear foot was estimated using the following data:

- Contractor bids for previous rehabilitation projects at BAAP
- Costs per linear foot of rehabilitation projects taken from case studies written for the AWWA
- Data from Means Mechanical Cost Data

A Life Cycle Cost Analysis (LCCA) was completed to determine the life cycle cost of rehabilitating these piping segments. Energy, chemical treatment, and maintenance cost savings for reducing current and future leakage was taken into consideration.

A summary of the LCCA is provided on the following page.

1. COMPONENT ARMY	FY 1995 MILITARY CONSTRUCTION PROJECT DATA	2. DATE May-95

3. INSTALLATION AND LOCATION
Badger Army Ammunition Plant; Baraboo, WI

4. PROJECT TITLE BAAP Water Conservation Study	5. PROJECT NUMBER

LIFE CYCLE COST ANALYSIS SUMMARY
ENERGY CONSERVATION INVESTMENT PROGRAM (ECIP)

LOCATION:	Badger Army Ammunition Plant	REGION: 2 (Wisconsin)		PROJECT NO:	1406-004
PROJECT TITLE:	Leak Detection Study			FISCAL YEAR:	1995
ANALYSIS DATE:	05/09/95	ECONOMIC LIFE:	20	PREPARED BY:	T. Poeling

1. INVESTMENT: **ECO #2 - Reline BAAP-Designated Problem Piping**

A.	CONSTRUCTION COST	=	$647,032	
B.	SIOH COST	(6.0% of 1A) =	$38,822	
C.	DESIGN COST	(6.0% of 1A) =	$38,822	
D.	TOTAL COST	(1A +1B +1C) =	$724,676	
E.	SALVAGE VALUE OF EXISTING EQUIPMENT =		$0	
F.	PUBLIC UTILITY COMPANY REBATE =		$0	
G.	TOTAL INVESTMENT	(1D -1E -1F) =	------->	$724,676

2. ENERGY SAVINGS (+) OR COST (-):
DATE OF NISTR 4942-1 USED FOR DISCOUNT FACTORS: BOD Oct 1994

	ENERGY SOURCE	FUEL COST $/KGAL (1)	SAVINGS KGAL/YR (2)	ANNUAL $ SAVINGS (3)	DISCOUNT FACTOR (4)	DISCOUNTED SAVINGS (5)	
A.	ELECT. (CURRENT)	$0.05	51,100	$2,402	15.88	$38,139	
B.	ELECT. (POTENTIAL)	$0.05	3,536	$166	15.88	$2,639	
C.	DIST	$5.00	0	$0	19.16	$0	
D.	NAT GAS	$4.00	0	$0	18.30	$0	
E.	COAL	$2.60	0	$0	16.62	$0	
G.	DEMAND (KW)	$6.82	0	$0	14.88	$0	
H.	TOTAL		54,636	$2,568		-------->	$40,778

3. NON-ENERGY SAVINGS (+) OR COST (-)

A. ANNUAL RECURRING (+/-)

1 WELL MAINTENANCE ($0.27/KGAL)	$14,752	14.88	$219,506
2 WATER DIST. MAINTENANCE ($1.22/KGAL)	$66,656	14.88	$991,840
3 CHEMICAL TREAT. SAVINGS ($0.032/KGAL)	$1,748	14.88	$26,015
4 TOTAL ANNUAL DISC. SAVINGS (+) / COST (-)	$83,156		$1,237,361

B. NON-RECURRING (+/-)

ITEM	SAVINGS (+) COST(-) (1)	YEAR OF OCCURRENCE (2)	DISCOUNT FACTOR (3) (TABLE A-2)	DISCOUNTED SAVINGS/ COST (4)
a.	$0		0.000	$0
b.	$0		0.000	$0
c.	$0		0.000	$0
d. TOTAL	$0			$0

C. TOTAL NON-ENERGY DISCOUNTED SAVINGS (+) OR COST (-) (3A4 + 3Bd4) = $1,237,361

4.	FIRST YEAR DOLLAR SAVINGS (+) / COSTS (-)	(2H3+3A+(3Bd1/Economic Life))	$85,724
5.	SIMPLE PAYBACK (SPB) IN YEARS (MUST BE < 10 YEARS TO QUALIFY)	(1G/4) =	8.45
6.	TOTAL NET DISCOUNTED SAVINGS	(2H5 + 3C) =	$1,278,139
7.	DISCOUNTED SAVINGS-TO-INVESTMENT RATIO (SIR) (MUST HAVE SIR > 1.25 TO QUALIFY)	(6/1G) =	1.76

PREVIOUS EDITIONS MAY BE USED INTERNALLY
UNTIL EXHAUSTED

ENGINEER'S OPINION OF PROBABLE COST

SHEET 1 OF 1

AREA	ACTIVITY	LOCATION	AMENDMENT NO.
Baraboo, Wisconsin	Leak Detection Study	Badger Army Ammunition Plant	

PROJECT TITLE	CONTRACT NO.
ECO #2 - RELINING PROBLEM PIPING AREAS	DACA01-94-D-0033

Line No.	Item Description	Unit of Measure	Qty.	MATERIAL COST		LABOR COST		EQUIPMENT COST		TOTAL COST	
				Unit Cost	Total	Unit Cost	Total	Unit Cost	Total	Unit Cost	Total
1	**RELINING PIPING**										
2	EXCAVATION	CY	1,080	$0.00	$0	$1.48	$1,598	$1.51	$1,631	$2.99	$3,229
3	DEWATERING	DAY	2	$0.00	$0	$67.50	$135	$7.80	$16	$75.30	$151
4	PIPE LINING, 12" (14")	LF	6,720	$14.30	$96,096	$21.70	$145,824	$0.64	$4,301	$36.64	$246,221
5	PIPE LINING, 24"	LF	4,890	$18.30	$89,487	$28.60	$139,854	$0.84	$4,108	$47.74	$233,449
6	CRUSHED ROCK BEDDING	CY	360	$13.00	$4,680	$3.28	$1,181	$1.33	$479	$17.61	$6,340
7	BACKFILL	CY	720	$0.00	$0	$0.68	$490	$0.56	$403	$1.24	$893
8	COMPACTION	CY	1,080	$0.00	$0	$0.82	$886	$0.32	$346	$1.14	$1,231
9				$0	$0	$0	$0	$0	$0	$0.00	$0
10				$0	$0	$0	$0	$0	$0	$0.00	$0
11				$0	$0	$0	$0	$0	$0	$0.00	$0
12				$0	$0	$0	$0	$0	$0	$0.00	$0
13											
14											
15											
16											
17	**CONSTRUCTION SUBTOTAL**				$190,263		$289,967		$11,282		$491,513
18	LOCATION FACTOR	%		**74.20%**	$141,175	**101.10%**	$293,157	**100.00%**	$11,282		$445,615
19	OVERHEAD & BOND	%	20		$28,235		$58,631		$2,256		$89,123
20	SUBTOTAL				$169,410		$351,788		$13,539		$534,738
21	PROFIT	%	10		$16,941		$35,179		$1,354		$53,474
22	SUBTOTAL				$186,351		$386,967		$14,893		$588,211
23	CONTINGENCY	%	10		$18,635		$38,697		$1,489		$58,821
24	**GRAND TOTAL**				$204,986		$425,664		$16,382		$647,032

PREPARED BY	APPROVED BY	TITLE OR ORGANIZATION	DATE
TCP		E M C Engineers, Inc.	5/2/95

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(404) 642-1864

JOB BAAP 1406-004
SHEET NO. 1 OF 1
CALCULATED BY TCP DATE 5-2-95
CHECKED BY DATE
SCALE ECO#2 - LCCA

ECO#2 - Rehabilitate BAAP Designated Problem Areas

Four sections of pipe were designated by BAAP as having excessive historical leakage. Those piping sections designated, total length, and nearest shutoff valve are:

Priority 1: 24" line
From Valve #281 (N16905, E3013)
To Valve #F-11 (N14461, E3013)
ϕ leaks surveyed
Total Length = 2,244 ft
Total number of (service) branches = 12
(8 serve Caretaker Areas)

Priority 2: 24" line
From Valve #368 (N16400, E2020)
To Valve #F-9 (N13756, E2023)
ϕ leaks surveyed
Total Length = 2,644 ft
Total number of (service) branches = 10
(6 serve Caretaker areas)

Priority 3: 14" line
From Valve #268 (N16765, E4885)
To Valve #341 (N13894, E4885)
2 leaks surveyed at 70,000 gpd
Total Length = 2,870 ft
Total number of (service) branches = 38

Priority 4: 14" line
From Valve #204 (N21109, E4245)
To Valve #242 (N18670, E4215)
2 leaks surveyed @ 70,000 gpd
Total Length = 2,440 ft
Total number of (service) branches = 22

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JOB BAAP 1406.004

CALCULATED BY TCP DATE 4-21-95
CHECKED BY DATE
SCALE

ECO #2 - Relining Pipe w/ Cement

Rehabilitation costs based on combination of Means Mechanical Cost Data, bids for relining projects at BAAP in 1990, and case studies from AWWA.

According to Means Mechanical (1994), lining pipe including bypass and cleaning, for rural areas (10,000 LF or greater)

	Material	Labor	Equip.	Total
14" pipe	$7.15	$10.85	$0.32	$18.32/LF
24" pipe	$9.15	$14.30	$0.42	$23.87/LF

According to 1990 bid for 4,300 L.F. of 24" pipe and 1,200 L.F. of 14" pipe. (5,500 LF total)

Bids received:
- Mainline Service $306,290 ($56/LF)
- Spinello Construction $185,000 ($34/LF)
- W. Walsh Co. $371,140 ($68/LF)

Case Studies from "Assessment of Existing and Development of Water Main Rehabilitation Practices (1990)"

- Washington Suburban Sanitary Commission = $27-28/LF (avg.)
- Los Angeles Dept. of Water/Power = $27/LF (1987)
- Table 7.3 (pg. 114) "Comparison of Contractor Cost for Various Rehabilitation Techniques" lists for cleaning + cement lining (18" < x < 32") typical cost = $22-58

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ECO #2 - Relining Pipe w/ Cement

Rehabilitation costs have been taken from 1990 bids and 1987 Reports. What is the present worth of those values today (1995)?

Assume: Inflation rate = 4%
For periods of 5 yrs and 8 yrs.

Therefore: $F_{1995} = P_{1990}$ (F/P, 4%, 5 yrs) =

From interest tables, (F/P, 4%, 5 yrs) = 1.2167
(F/P, 4%, 8 yrs) = 1.3686

Listing of Cement Lining Prices (1995 prices)

Location	Year of Study	Cost	1995 Cost
Means Mechanical	1994	-	$23.87/LF
Washington Suburban	1987	$28/LF	$38.32/LF
L.A. Dept. of Water	1987	$27/LF	$36.95/LF
Spiniello Construction	1990	$34/LF	$41.37/LF
Mainline Service	1990	$56/LF	$68.14/LF
W. Walsh Co.	1990	$68/LF	$82.74/LF
			$291.39/LF

Mean Cost (Avg.) = $48.55/LF
Median Cost = $40/LF

Bid 1/30/1990

RAYMOND INTERNATIONAL BUILDERS 365 PASSIAC STREET ROCHELLE, NY 07662	None
MAINLINE SERVICE P. O. BOX 96 ELMA, NY 14059	$306,290-
AMERON PIPE LINING DIVISION 360 CARNEGIE AVENUE P. O. BOX 67 KENILWORTH, NJ 07033	None
SPINIELLO CONSTRUCTION COMPANY 25 AIRPORT ROAD MORRISTOWN, NJ 07960	$185,000-
AMERON PIPE LINING DIVISION P. O. BOX 22613 LONG BEACH, CA 90801-5613	None
W. WALSH COMPANY, INC. 32 WALTON STREET ATTLEBORO, MA 02703	$371,140-
HEITKAMP, INC. 99 CALLENDAR ROAD P. O. BOX 730 WATERTOWN, CT 06795	None

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ECO #2 - Cost Estimate

Another reason that rehabilitating piping is more economical than replacing piping is that the entire length of piping does not need to be excavated. Only access points need to be excavated.

Assume access points are required every ≈500 ft:
- Priority 1 - Length = 2,244 ft. ⇒ Assume 4 access pts.
- Priority 2 - Length = 2,644 ft. ⇒ Assume 5 access pts.
- Priority 3 - Length = 2,870 ft. ⇒ Assume 6 access pts.
- Priority 4 - Length = 2,440 ft. ⇒ Assume 5 access pts.

Total: 20 access pts.

- Excavate: (9 yds L)×(3 yds W)×(2 yds D) = 54 yds ea.
  Total excavation = (20 pts)(54 yds ea) = 1,080 CY
- Backfill bedding: (9 yds L)×(3 yds W)×(2/3 yd D) = 18 yds ea.
  Total bedding: (20 pts)(18 yds ea) = 360 CY
- Backfill soil: 1080 CY - 360 CY = 720 CY

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ECO #2 - Cost Estimate (cont)

For pipe replacement, the entire length of pipe must be excavated and backfilled, thus increasing costs.

Excavation

Assume excavating 3' W × 6' D = 18 CF/LF piping
= 0.667 CY/LF

For total length = 10,200 L.F., total excavation = 6,800 C.Y.

Backfill - Bedding

Assume bedding 3' W × 2' D = 6 CF/LF piping
= ~~0.333~~ 0.222 CY/LF

For total length = 10,200 LF, total bedding = 2,260 CY

Backfill - Soil

Backfill is difference between excavation + bedding backfill
Backfill (Soil) = 6,800 - 2,260 = 4,540 CY

1. COMPONENT ARMY	FY 1995 MILITARY CONSTRUCTION PROJECT DATA	2. DATE May-95

3. INSTALLATION AND LOCATION Badger Army Ammunition Plant; Baraboo, WI	4. PROJECT TITLE Isolate Piping in "Caretaker" Areas

5. PROGRAM ELEMENT	6. CATEGORY CODE	7. PROJECT NUMBER	8. PROJECT COST ($000)

9. COST ESTIMATES

ITEM	U/M	QUANTITY	UNIT COST	COST
ECIP: Isolate Piping in "Caretaker" Areas	LS			$63,753
TOTAL CONTRACT COST				63,753
SIOH (6%)				3,825
DESIGN COST (6%)				3,825
TOTAL PROJECT COST				71,403
TOTAL REQUEST (ROUNDED)				72,000

10. DESCRIPTION OF PROPOSED CONSTRUCTION

"Caretaker" areas are designated by Badger Army Ammunition Plant (BAAP) as including those buildings that no longer require fire protection. There are six areas at BAAP that consist of enough "Caretaker" buildings to the extent that fire protection service can be completely shut off. Cap off process water piping to isolate the following designated "Caretaker " areas: Area #8 (E-Line NC), Area #1 (Old Acid Area), Area #12 (West Section of D-Line SB), Area #13 (West Section of E-Line SB), Area #9 (F-Line NC), and Area #18 (Rocket Area East).

11. REQUIREMENT:

Project: This Energy Conservation Investment Program (ECIP) project will cap off process water piping in order to isolate six areas at BAAP designated as being in "Caretaker" status.

Requirement: This project is required to reduce process water usage at BAAP. A reduction of leakage in the process water system would result in immediate energy and maintenance savings.

Current Situation: Currently, BAAP pumps approximately 250,900,000 gallons of water per year into the process water system. A water audit has revealed that, of this amount, about 116,734,000 gallons of water (46%) is in the form of leakage that can be recovered. A recent leak detection survey revealed that approximately 4,745,000 gallons per year are lost through leakage in these six "Caretaker" areas. If the process water piping that serve these areas are capped, current and future leakage in those areas are eliminated. The result would be significant energy, maintenance and chemical treatment cost savings.

Impact If Not Provided: Failure to implement this project will cause BAAP to not realize a $29,391 annual savings with a 2.43 year simple payback and a savings-to-investment ratio of 6.14.

Supporting Documentation: Supporting data for basic engineering calculations which show energy and maintenance cost savings are documented in a report under COE Contract No. DACA01-94-D-0033, performed by an A/E firm in FY95.

Verification of Savings: Process water system pumps have existing meters which display the amount of water pumped to the process water system. These meters are read on a monthly basis. Historic data was obtained for the period of January 1992 through September 1994 as a basis for the report mentioned above. The amount of water pumped for the period subsequent to the ECIP project implementation can be used to compare the quantity of water pumped after the ECIP project is implemented. Assuming that the process water demand has remained fairly constant, the amount of water saved in repairing the leakage should be the difference.

1. COMPONENT ARMY	FY 1995 MILITARY CONSTRUCTION PROJECT DATA	2. DATE May-95
3. INSTALLATION AND LOCATION Badger Army Ammunition Plant; Baraboo, WI		
4. PROJECT TITLE Isolate Piping in "Caretaker" Areas		5. PROJECT NUMBER

Amount of Water Conserved: The amount of water conserved is estimated to be 18,732,000 gallons per year.

ECONOMIC ANALYSIS

Process water is distributed throughout BAAP by a multi-looped system comprised of approximately 120 miles of piping. The piping network, which is primarily comprised of steel and cast iron mains, was constructed in the 1940's. The primary demand for the process water system is to provide fire protection for the buildings at BAAP. However, the majority of water consumption is due to leakage in distribution piping, valves and fire hydrants.

BAAP has been in standby status since 1975. Many of the buildings at BAAP are not being utilized and their status is not anticipated to change in the near future. BAAP has classified these buildings, located in eighteen separate areas, as having "Caretaker" status. By definition and from conversations with BAAP personnel, it is assumed that their value has depreciated to the point that fire protection is not required. BAAP has classified buildings in eighteen different areas as "Caretaker". However, only six areas consist of enough "Caretaker" buildings to the extent that fire protection can be completely shut off. Those six areas, along with the valves used that should be used to isolate them, consist of:

- **Area #8 (E-Line NC).** Isolate at valves #193, #322, #324, #336, and #338.
- **Area #1 (Old Acid).** Isolate at valves #237, #254, and #257.
- **Area #12 (D Line SB).** Isolate valves #308, #309, #310 and PRV at coordinate North 15,985 and East 3,092.
- **Area #13 (E Line SB).** Isolate at valves #325, #326, #334, #337 and PRV's at coordinate North 14,940 and East 3,090 and coordinates North 14,945 and East 3,760.
- **Area #9 (F Line NC).** Isolate at valves #F-1, #F-3, #F-4, and #F-6.
- **Area #18 (Rocket East).** Isolate at valves #41, #45, #48, #51, #52, #104, #135, #137, #138, #138A, and #162.

If the process water piping lines that serve these areas are capped, current and future leakage would be eliminated. The result would be significant energy, maintenance, and chemical treatment savings.

The value of the water lost to leakage is based on several factors:

- **Pump Electrical Consumption**. Process water will be pumped into the distribution system primarily by a 500 gpm pump with a 40 hp motor. The pump is located at the Pump & Treat (IRM) Facility. Well No. 4, with a capacity of 935 gpm and a 100 hp motor, supplements the IRM Facility pump during periods of peak demand and maintenance. A reduction of leakage in the process water distribution system would reduce the amount of water that is pumped, thus saving electrical energy consumed by the pumps.
- **Chemical Treatment**. Chlorine is currently fed into the process water system at the source. High quality, bacteria-free water is required for production and domestic uses. Because chlorine is injected per volume of process water pumped, reducing the amount of leakage lost would reduce the amount of chlorine required.

1. COMPONENT ARMY	FY 1995 MILITARY CONSTRUCTION PROJECT DATA	2. DATE May-95
3. INSTALLATION AND LOCATION Badger Army Ammunition Plant; Baraboo, WI		
4. PROJECT TITLE Isolate Piping in "Caretaker" Areas		5. PROJECT NUMBER

ECONOMIC ANALYSIS (cont.)

- **Well Maintenance.** Money is annually budgeted to maintain the five wells at BAAP. Two of the wells (No. 4 & 5) are used as sources for the process water system. Decreased operating time for the well pumps will reduce the amount of maintenance required for pumps and pump motors.
- **Distribution Maintenance.** BAAP uses a maintenance crew to repair leakage in the distribution system. If leakage can be reduced in the distribution system, fewer labor hours will be needed to located and repair leakage.

A leak detection survey was performed in October 1994 to locate and quantify current leakage in the process water system. Eight leaks were found in piping in these six "Caretaker" areas. The total amount of water currently lost to leakage was estimated at 4,745,000 gallons per year (13,000 gpd).

Potential leakage in piping in these "Caretaker" areas was predicted using a leakage density factor. The leakage density factor was calculated using the total amount of recoverable leakage in the entire process water system and dividing by the total length of pipe for each diameter. The validity of the leakage density factor is based on the assumption that the process water system is constructed with the same percentage of material throughout, is approximately the same age, is installed in soil with similar characteristics, and is located under land that is used for essentially the same industrial purposes. Multiplying the total length of the various diameter piping located in these "Caretaker" areas by the leakage density factor of 0.046 gpd per linear foot per diameter of piping, the value for future leakage was estimated to be 13,987,000 gallons per year.

A cost estimate was created to determine the cost of isolating each specific area from the process water system. Isolating the area will involve excavating and capping off the piping. The pipe will be capped near a main line valve, which would be used to isolate the flow.

A Life Cycle Cost Analysis (LCCA) was completed to determine the life cycle cost of isolating each "Caretaker" area. Energy, chemical treatment, and maintenance cost savings for reducing current and future leakage was taken into consideration.

A summary of the LCCA is provided on the following page.

1. COMPONENT ARMY	FY 1995 MILITARY CONSTRUCTION PROJECT DATA	2. DATE May-95
3. INSTALLATION AND LOCATION Badger Army Ammunition Plant; Baraboo, WI		
4. PROJECT TITLE BAAP Water Conservation Study		5. PROJECT NUMBER

LIFE CYCLE COST ANALYSIS SUMMARY
ENERGY CONSERVATION INVESTMENT PROGRAM (ECIP)

LOCATION:	Badger Army Ammunition Plant	REGION: 2 (Wisconsin)		PROJECT NO:	1406-004
PROJECT TITLE:	Leak Detection Study			FISCAL YEAR:	1995
ANALYSIS DATE:	05/09/95	ECONOMIC LIFE:	20	PREPARED BY:	T. Poeling

1. INVESTMENT: **ECO #3 - Isolate 'Caretaker' Areas**

A. CONSTRUCTION COST	= =		$63,753	
B. SIOH COST	(6.0% of 1A) =		$3,825	
C. DESIGN COST	(6.0% of 1A) =		$3,825	
D. TOTAL COST	(1A +1B +1C) =		$71,403	
E. SALVAGE VALUE OF EXISTING EQUIPMENT =			$0	
F. PUBLIC UTILITY COMPANY REBATE =				
G. TOTAL INVESTMENT	(1D -1E -1F) =		------->	$71,403

2. ENERGY SAVINGS (+) OR COST (-):

DATE OF NISTR 4942-1 USED FOR DISCOUNT FACTORS: BOD Oct 1994

ENERGY SOURCE	FUEL COST $/KGAL (1)	SAVINGS KGAL/YR (2)	ANNUAL $ SAVINGS (3)	DISCOUNT FACTOR (4)	DISCOUNTED SAVINGS (5)	
A. ELECT. (CURRENT)	$0.05	4,745	$223	15.88	$3,541	
B. ELECT. (POTENTIAL)	$0.05	13,987	$657	15.88	$10,439	
C. DIST	$5.00	0	$0	19.16	$0	
D. NAT GAS	$4.00	0	$0	18.30	$0	
E. COAL	$2.60	0	$0	16.62	$0	
G. DEMAND SAV'GS (KW)	$6.82	0	$0	14.88	$0	
H. TOTAL		18,732	$880		-------->	$13,981

3. NON-ENERGY SAVINGS (+) OR COST (-)

A. ANNUAL RECURRING (+/-)

1 WELL MAINTENANCE ($0.27/KGAL)	$5,058	14.88	$75,258
2 WATER DIST. MAINTENANCE ($1.22/KGAL)	$22,853	14.88	$340,053
3 CHEMICAL TREAT. SAVINGS ($0.032/KGAL)	$599	14.88	$8,919
4 TOTAL ANNUAL DISC. SAVINGS (+) / COST (-)	$28,510		$424,230

B. NON-RECURRING (+/-)

ITEM	SAVINGS (+) COST(-) (1)	YEAR OF OCCURRENCE (2)	DISCOUNT FACTOR (3) (TABLE A-2)	DISCOUNTED SAVINGS/ COST (4)
a.				$0
b.				$0
c.				$0
d. TOTAL	$0			$0

C. TOTAL NON-ENERGY DISCOUNTED SAVINGS (+) OR COST (-) (3A4 + 3Bd4) = $424,230

4. FIRST YEAR DOLLAR SAVINGS (+) / COSTS (-)	(2H3+3A+(3Bd1/Economic Life))	$29,391
5. SIMPLE PAYBACK (SPB) IN YEARS (MUST BE < 10 YEARS TO QUALIFY)	(1G/4) =	2.43
6. TOTAL NET DISCOUNTED SAVINGS	(2H5 + 3C) =	$438,211
7. DISCOUNTED SAVINGS-TO-INVESTMENT RATIO (SIR) (MUST HAVE SIR > 1.25 TO QUALIFY)	(6/1G) =	6.14

ENGINEER'S OPINION OF PROBABLE COST

SHEET 1 OF 7

AREA	ACTIVITY	LOCATION	AMENDMENT NO.
	Leak Detection Study	Badger Army Ammunition Plant	

PROJECT TITLE	CONTRACT NO.
ECO #3A - FIX LEAKS IN SPECIFIC CARETAKER AREAS (AREA #8)	DACA01-94-D-0033

Line No.	Item Description	Unit of Measure	Qty.	MATERIAL COST Unit Cost	MATERIAL COST Total	LABOR COST Unit Cost	LABOR COST Total	EQUIPMENT COST Unit Cost	EQUIPMENT COST Total	TOTAL COST Unit Cost	TOTAL COST Total
1	**ISOLATE E-LINE NC**										
2	EXCAVATION	CY	28	$0.00	$0	$1.48	$41	$1.51	$42	$2.99	$84
3	DEWATERING	DAY	3	$0.00	$0	$67.50	$203	$7.80	$23	$75.30	$226
4	VALVE DEMOLITION, TO 16"	EA	2	$0.00	$0	$50.00	$100	$0.00	$0	$50.00	$100
5	VALVE DEMOLITION, TO 24"	EA	3	$0.00	$0	$50.00	$150	$0.00	$0	$50.00	$150
6	BLIND FLANGE, 16"	EA	3	$865.00	$2,595	$315.00	$945	$0.00	$0	$1,180.00	$3,540
7	BLIND FLANGE, 24"	EA	2	$2,425.00	$4,850	$635.00	$1,270	$0.00	$0	$3,060.00	$6,120
8	BACKFILL	CY	28	$0.00	$0	$0.68	$19	$0.56	$16	$1.24	$35
9	COMPACTION	CY	28	$0.00	$0	$0.82	$23	$0.32	$9	$1.14	$32
10				$0	$0	$0	$0	$0	$0	$0.00	$0
11				$0	$0	$0	$0	$0	$0	$0.00	$0
12				$0	$0	$0	$0	$0	$0	$0.00	$0
13											
14											
15											
16											
17	**CONSTRUCTION SUBTOTAL**				$7,445		$2,751		$90		$10,286
18	LOCATION FACTOR			**74.20%**	$5,524	**101.10%**	$2,781	**100.00%**	$90		$8,396
19	OVERHEAD & BOND	%	20		$1,105		$556		$18		$1,679
20	SUBTOTAL				$6,629		$3,337		$108		$10,075
21	PROFIT	%	10		$663		$334		$11		$1,007
22	SUBTOTAL				$7,292		$3,671		$119		$11,082
23	CONTINGENCY	%	10		$729		$367		$12		$1,108
24	**GRAND TOTAL**				$8,021		$4,038		$131		$12,191

PREPARED BY	APPROVED BY	TITLE OR ORGANIZATION	DATE
TCP		E M C Engineers, Inc.	1/20/95

ENGINEER'S OPINION OF PROBABLE COST

SHEET 2 OF 7

AREA	ACTIVITY	LOCATION	AMENDMENT NO.
	Leak Detection Study	Badger Army Ammunition Plant	

PROJECT TITLE	CONTRACT NO.
ECO #3B - FIX LEAKS IN SPECIFIC CARETAKER AREAS (AREA #1)	DACA01-94-D-0033

Line No.	Item Description	Unit of Measure	Qty.	MATERIAL COST Unit Cost	MATERIAL COST Total	LABOR COST Unit Cost	LABOR COST Total	EQUIPMENT COST Unit Cost	EQUIPMENT COST Total	TOTAL COST Unit Cost	TOTAL COST Total
1	**ISOLATE OLD ACID AREA**										
2	EXCAVATION	CY	11	$0.00	$0	$1.48	$16	$1.51	$17	$2.99	$33
3	DEWATERING	DAY	1	$0.00	$0	$67.50	$68	$7.80	$8	$75.30	$75
4	VALVE DEMOLITION, TO 24"	EA	2	$0.00	$0	$50.00	$100	$0.00	$0	$50.00	$100
5	BLIND FLANGE, 24"	EA	2	$2,425.00	$4,850	$635.00	$1,270	$0.00	$0	$3,060.00	$6,120
6	BACKFILL	EA	11	$0.00	$0	$0.68	$8	$0.56	$6	$1.24	$14
7	COMPACTION	EA	11	$0.00	$0	$0.82	$9	$0.32	$4	$1.14	$13
8				$0	$0	$0	$0	$0	$0	$0.00	$0
9				$0	$0	$0	$0	$0	$0	$0.00	$0
10				$0	$0	$0	$0	$0	$0	$0.00	$0
11				$0	$0	$0	$0	$0	$0	$0.00	$0
12				$0	$0	$0	$0	$0	$0	$0.00	$0
13											
14											
15											
16											
17	**CONSTRUCTION SUBTOTAL**				$4,850		$1,471		$34		$6,355
18	LOCATION FACTOR			**74.20%**	$3,599	**101.10%**	$1,487	**100.00%**	$34		$5,120
19	OVERHEAD & BOND	%	20		$720		$297		$7		$1,024
20	SUBTOTAL				$4,318		$1,784		$41		$6,144
21	PROFIT	%	10		$432		$178		$4		$614
22	SUBTOTAL				$4,750		$1,963		$45		$6,758
23	CONTINGENCY	%	10		$475		$196		$5		$676
24	**GRAND TOTAL**				$5,225		$2,159		$50		$7,434

PREPARED BY	APPROVED BY	TITLE OR ORGANIZATION	DATE
TCP		E M C Engineers, Inc.	1/20/95

ENGINEER'S OPINION OF PROBABLE COST

AREA	**ACTIVITY** Leak Detection Study	**LOCATION** Badger Army Ammunition Plant	**SHEET** 3 **OF** 7
			AMENDMENT NO.
PROJECT TITLE ECO #3C - FIX LEAKS IN SPECIFIC CARETAKER AREAS (AREA #12)			**CONTRACT NO.** DACA01-94-D-0033

Line No.	Item Description	Unit of Measure	Qty.	MATERIAL COST Unit Cost	MATERIAL COST Total	LABOR COST Unit Cost	LABOR COST Total	EQUIPMENT COST Unit Cost	EQUIPMENT COST Total	TOTAL COST Unit Cost	TOTAL COST Total
1	**ISOLATE D-LINE SB AREA**										
2	EXCAVATION	CY	22	$0.00	$0	$1.48	$33	$1.51	$34	$2.99	$66
3	DEWATERING	DAY	2	$0.00	$0	$67.50	$135	$7.80	$16	$75.30	$151
4	VALVE DEMOLITION, TO 16"	EA	4	$0.00	$0	$50.00	$200	$0.00	$0	$50.00	$200
5	BLIND FLANGE, 10"	EA	2	$350.00	$700	$186.00	$372	$0.00	$0	$536.00	$1,072
6	BLIND FLANGE, 16"	EA	2	$865.00	$1,730	$315.00	$630	$0.00	$0	$1,180.00	$2,360
7	BACKFILL	EA	22	$0.00	$0	$0.68	$15	$0.56	$12	$1.24	$28
8	COMPACTION	EA	22	$0.00	$0	$0.82	$18	$0.32	$7	$1.14	$25
9				$0	$0	$0	$0	$0	$0	$0.00	$0
10				$0	$0	$0	$0	$0	$0	$0.00	$0
11				$0	$0	$0	$0	$0	$0	$0.00	$0
12				$0	$0	$0	$0	$0	$0	$0.00	$0
13											
14											
15											
16											
17	**CONSTRUCTION SUBTOTAL**				$2,430		$1,403		$69		$3,902
18	LOCATION FACTOR			**74.20%**	$1,803	**101.10%**	$1,419	**100.00%**	$69		$3,290
19	OVERHEAD & BOND	%	20		$361		$284		$14		$658
20	SUBTOTAL				$2,164		$1,702		$82		$3,948
21	PROFIT	%	10		$216		$170		$8		$395
22	SUBTOTAL				$2,380		$1,873		$91		$4,343
23	CONTINGENCY	%	10		$238		$187		$9		$434
24	**GRAND TOTAL**				$2,618		$2,060		$100		$4,778

PREPARED BY	APPROVED BY	TITLE OR ORGANIZATION	DATE
TCP		E M C Engineers, Inc.	1/20/95

ENGINEER'S OPINION OF PROBABLE COST

SHEET 4 **OF** 7

AREA	**ACTIVITY**	**LOCATION**	**AMENDMENT NO.**
	Leak Detection Study	Badger Army Ammunition Plant	

PROJECT TITLE
ECO #3D - FIX LEAKS IN SPECIFIC CARETAKER AREAS (AREA #13)

CONTRACT NO.
DACA01-94-D-0033

Line No.	Item Description	Unit of Measure	Qty.	MATERIAL COST Unit Cost	MATERIAL COST Total	LABOR COST Unit Cost	LABOR COST Total	EQUIPMENT COST Unit Cost	EQUIPMENT COST Total	TOTAL COST Unit Cost	TOTAL COST Total
1	**ISOLATE E-LINE SB AREA**										
2	EXCAVATION	CY	33	$0.00	$0	$1.48	$49	$1.51	$50	$2.99	$100
3	DEWATERING	DAY	3	$0.00	$0	$67.50	$203	$7.80	$23	$75.30	$226
4	VALVE DEMOLITION, TO 16"	EA	4	$0.00	$0	$50.00	$200	$0.00	$0	$50.00	$200
5	VALVE DEMOLITION, TO 24"	EA	2	$0.00	$0	$50.00	$100	$0.00	$0	$50.00	$100
6	BLIND FLANGE, 10"	EA	2	$350.00	$700	$186.00	$372	$0.00	$0	$536.00	$1,072
7	BLIND FLANGE, 16"	EA	2	$865.00	$1,730	$315.00	$630	$0.00	$0	$1,180.00	$2,360
8	BLIND FLANGE, 24"	EA	2	$2,425.00	$4,850	$635.00	$1,270	$0.00	$0	$3,060.00	$6,120
9	BACKFILL	EA	33	$0.00	$0	$0.68	$23	$0.56	$19	$1.24	$41
10	COMPACTION	EA	33	$0.00	$0	$0.82	$27	$0.32	$11	$1.14	$38
11				$0	$0	$0	$0	$0	$0	$0.00	$0
12				$0	$0	$0	$0	$0	$0	$0.00	$0
13											
14											
15											
16											
17	**CONSTRUCTION SUBTOTAL**				$7,280		$2,874		$103		$10,257
18	LOCATION FACTOR			**74.20%**	$5,402	**101.10%**	$2,905	**100.00%**	$103		$8,410
19	OVERHEAD & BOND	%	20		$1,080		$581		$21		$1,682
20	SUBTOTAL				$6,482		$3,486		$124		$10,092
21	PROFIT	%	10		$648		$349		$12		$1,009
22	SUBTOTAL				$7,130		$3,835		$136		$11,101
23	CONTINGENCY	%	10		$713		$384		$14		$1,110
24	**GRAND TOTAL**				$7,843		$4,219		$150		$12,211

PREPARED BY	**APPROVED BY**	**TITLE OR ORGANIZATION**	**DATE**
TCP		E M C Engineers, Inc.	1/20/95

ENGINEER'S OPINION OF PROBABLE COST

AREA	ACTIVITY	LOCATION	AMENDMENT NO.
	Leak Detection Study	Badger Army Ammunition Plant	

PROJECT TITLE	CONTRACT NO.
ECO #3E - FIX LEAKS IN SPECIFIC CARETAKER AREAS (AREA #09)	DACA01-94-D-0033

Line No.	Item Description	Unit of Measure	Qty.	MATERIAL COST Unit Cost	MATERIAL COST Total	LABOR COST Unit Cost	LABOR COST Total	EQUIPMENT COST Unit Cost	EQUIPMENT COST Total	TOTAL COST Unit Cost	TOTAL COST Total
1	**ISOLATE F-LINE NC AREA**										
2	EXCAVATION	CY	28	$0.00	$0	$1.48	$41	$1.51	$42	$2.99	$83
3	DEWATERING	DAY	3	$0.00	$0	$67.50	$169	$7.80	$20	$75.30	$188
4	VALVE DEMOLITION, TO 16"	EA	3	$0.00	$0	$50.00	$150	$0.00	$0	$50.00	$150
5	VALVE DEMOLITION, TO 24"	EA	2	$0.00	$0	$50.00	$100	$0.00	$0	$50.00	$100
6	BLIND FLANGE, 16"	EA	3	$865.00	$2,595	$315.00	$945	$0.00	$0	$1,180.00	$3,540
7	BLIND FLANGE, 24"	EA	2	$2,425.00	$4,850	$635.00	$1,270	$0.00	$0	$3,060.00	$6,120
8	BACKFILL	EA	28	$0.00	$0	$0.68	$19	$0.56	$16	$1.24	$34
9	COMPACTION	EA	28	$0.00	$0	$0.82	$23	$0.32	$9	$1.14	$32
10				$0	$0	$0	$0	$0	$0	$0.00	$0
11				$0	$0	$0	$0	$0	$0	$0.00	$0
12				$0	$0	$0	$0	$0	$0	$0.00	$0
13											
14											
15											
16											
17	**CONSTRUCTION SUBTOTAL**				$7,445		$2,716		$86		$10,247
18	LOCATION FACTOR			74.20%	$5,524	101.10%	$2,746	100.00%	$86		$8,356
19	OVERHEAD & BOND	%	20		$1,105		$549		$17		$1,671
20	SUBTOTAL				$6,629		$3,296		$103		$10,028
21	PROFIT	%	10		$663		$330		$10		$1,003
22	SUBTOTAL				$7,292		$3,625		$113		$11,030
23	CONTINGENCY	%	10		$729		$363		$11		$1,103
24	**GRAND TOTAL**				$8,021		$3,988		$125		$12,133

PREPARED BY	APPROVED BY	TITLE OR ORGANIZATION	DATE
TCP		E M C Engineers, Inc.	1/20/95

ENGINEER'S OPINION OF PROBABLE COST

SHEET 6 **OF** 7			
AREA	**ACTIVITY** Leak Detection Study	**LOCATION** Badger Army Ammunition Plant	**AMENDMENT NO.**
PROJECT TITLE ECO #3F - FIX LEAKS IN SPECIFIC CARETAKER AREAS (AREA #18)		**CONTRACT NO.** DACA01-94-D-0033	

Line No.	Item Description	Unit of Measure	Qty.	MATERIAL COST Unit Cost	MATERIAL COST Total	LABOR COST Unit Cost	LABOR COST Total	EQUIPMENT COST Unit Cost	EQUIPMENT COST Total	TOTAL COST Unit Cost	TOTAL COST Total
1	**ISOLATE ROCKET EAST**										
2	EXCAVATION	CY	61	$0.00	$0	$1.48	$90	$1.51	$92	$2.99	$182
3	DEWATERING	DAY	6	$0.00	$0	$67.50	$371	$7.80	$43	$75.30	$414
4	VALVE DEMOLITION, TO 16"	EA	11	$0.00	$0	$50.00	$550	$0.00	$0	$50.00	$550
5	BLIND FLANGE, 12"	EA	4	$470.00	$1,880	$226.00	$904	$0.00	$0	$696.00	$2,784
6	BLIND FLANGE, 16"	EA	7	$865.00	$6,055	$315.00	$2,205	$0.00	$0	$1,180.00	$8,260
7	BACKFILL	EA	61	$0.00	$0	$0.68	$41	$0.56	$34	$1.24	$76
8	COMPACTION	EA	61	$0.00	$0	$0.82	$50	$0.32	$20	$1.14	$70
9				$0	$0	$0	$0	$0	$0	$0.00	$0
10				$0	$0	$0	$0	$0	$0	$0.00	$0
11				$0	$0	$0	$0	$0	$0	$0.00	$0
12				$0	$0	$0	$0	$0	$0	$0.00	$0
13											
14											
15											
16											
17	**CONSTRUCTION SUBTOTAL**				$7,935		$4,212		$189		$12,336
18	LOCATION FACTOR			**74.20%**	$5,888	**101.10%**	$4,258	**100.00%**	$189		$10,335
19	OVERHEAD & BOND	%	20		$1,178		$852		$38		$2,067
20	SUBTOTAL				$7,065		$5,110		$226		$12,402
21	PROFIT	%	10		$707		$511		$23		$1,240
22	SUBTOTAL				$7,772		$5,621		$249		$13,642
23	CONTINGENCY	%	10		$777		$562		$25		$1,364
24	**GRAND TOTAL**				$8,549		$6,183		$274		$15,006

PREPARED BY	APPROVED BY	TITLE OR ORGANIZATION	DATE
TCP		E M C Engineers, Inc.	1/20/95

ENGINEER'S OPINION OF PROBABLE COST

AREA	ACTIVITY	LOCATION	AMENDMENT NO.
	Leak Detection Study	Badger Army Ammunition Plant	

PROJECT TITLE
ECO #3 - ISOLATE ALL CARETAKER AREAS

CONTRACT NO.
DACA01-94-D-0033

Line No.	Item Description	Unit of Measure	Qty.	MATERIAL COST		LABOR COST		EQUIPMENT COST		TOTAL COST	
				Unit Cost	Total	Unit Cost	Total	Unit Cost	Total	Unit Cost	Total
1	SUMMARY										
2	ECO #3A - ISOLATE AREA #8	EA	1		$7,445		$2,751		$90		$10,286
3	ECO #3B - ISOLATE AREA #1	EA	1		$4,850		$1,471		$34		$6,355
4	ECO #3C - ISOLATE AREA #12	EA	1		$2,430		$1,403		$69		$3,902
5	ECO #3D - ISOLATE AREA #13	EA	1		$7,280		$2,874		$103		$10,257
6	ECO #3E - ISOLATE AREA #9	EA	1		$7,445		$2,716		$86		$10,247
7	ECO #3F - ISOLATE AREA #18	EA	1		$7,935		$4,212		$189		$12,336
8											
9											
10											
11											
12											
13											
14											
15											
16											
17	CONSTRUCTION SUBTOTAL				$37,385		$15,427		$571		$53,383
18	LOCATION FACTOR	%		74.20%	$27,740	101.10%	$15,597	100.00%	$571		$43,907
19	OVERHEAD & BOND	%	20		$5,548		$3,119		$114		$8,781
20	SUBTOTAL				$33,288		$18,716		$685		$52,688
21	PROFIT	%	10		$3,329		$1,872		$68		$5,269
22	SUBTOTAL				$36,616		$20,587		$753		$57,957
23	CONTINGENCY	%	10		$3,662		$2,059		$75		$5,796
24	GRAND TOTAL				$40,278		$22,646		$829		$63,753

PREPARED BY	APPROVED BY	TITLE OR ORGANIZATION	DATE
TCP		E M C Engineers, Inc.	1/20/95

1. COMPONENT ARMY	FY 1995 MILITARY CONSTRUCTION PROJECT DATA	2. DATE May-95

3. INSTALLATION AND LOCATION	4. PROJECT TITLE
Badger Army Ammunition Plant; Baraboo, WI	Implement Leak Detection Program

5. PROGRAM ELEMENT	6. CATEGORY CODE	7. PROJECT NUMBER	8. PROJECT COST ($000)

9. COST ESTIMATES

ITEM	U/M	QUANTITY	UNIT COST	COST
ECIP: Implement Water Audit & Leak Detection Program	LS			$15,750
TOTAL CONTRACT COST				15,750
SIOH (6%)				945
DESIGN COST (6%)				945
TOTAL PROJECT COST				17,640
TOTAL REQUEST (ROUNDED)				18,000

10. DESCRIPTION OF PROPOSED CONSTRUCTION

Implement a water audit and leak detection program for approximately 105 miles of process water system at the Badger Army Ammunition Plant (BAAP). The leak detection program does not include approximately 15 miles of process water piping in various "Caretaker" areas that have been capped off and isolated.

11. REQUIREMENT:

Project: This Energy Conservation Investment Program (ECIP) project will implement a water audit and leak detection program for the process water system at BAAP.

Requirement: This project is required to reduce process water usage at BAAP. A reduction of leakage in the process water system would result in immediate energy and maintenance savings.

Current Situation: BAAP pumps approximately 250,900,000 gallons of water per year into the process water system. Once projects are performed to rehabilitate four sections of pipe and to cap off piping to isolate six areas that no longer required process water ("Caretaker" areas), approximately 177,532,000 gallons of process water per year will be pumped. A water audit has revealed that, of this amount, about 61,708,000 gallons of water (35%) is in the form of leakage that can be recovered. It is BAAP's policy that leakage that is discovered in a leak detection survey will be immediately excavated and repaired.

Impact If Not Provided: Failure to implement this project will cause BAAP to not realize a $21,536 annual savings with a 0.82 year simple payback and a savings-to-investment ratio of 18.33.

Supporting Documentation: Supporting data for basic engineering calculations which show energy savings and cost savings are documented in a report under COE Contract No. DACA01-94-D-0033, performed by an A/E firm in FY95.

Verification of Savings: Process water system pumps have existing meters which display the amount of water pumped to the process water system. These meters are read on a monthly basis. Historic data was obtained for the period of January 1992 through September 1994 as a basis for the report mentioned above. The amount of water pumped for the period subsequent to the ECIP project implementation can be used to compare the quantity of water pumped after the ECIP project is implemented. Assuming that the process water demand has remained fairly constant, the amount of water saved in repairing the leakage should be the difference.

Amount of Water Conserved: The amount of water conserved is estimated to be 61,708,000 gallons per year.

1. COMPONENT ARMY	FY 1995 MILITARY CONSTRUCTION PROJECT DATA	2. DATE May-95
3. INSTALLATION AND LOCATION Badger Army Ammunition Plant; Baraboo, WI		
4. PROJECT TITLE Implement Leak Detection Program		5. PROJECT NUMBER

ECONOMIC ANALYSIS

A water audit was performed on the process water system at BAAP according to the guidelines set by American Water Works Association (AWWA) Manual 36, entitled "Water Audits and Leak Detection". The audit was based on information supplied by BAAP personnel. Water usage in the process water system can be separated into the following categories:

- **Fire Protection**. Each fire hydrant is exercised for approximately 10 minutes each summer. There are approximately 675 hydrants at BAAP.
- **Industrial Uses**. Process water is used for steam production and as a once-through cooling system at the Powerhouse, for some domestic uses, and for maintenance activities such as tank cleaning.
- **Irrigation Water for Cattle**. In the summer months, water is taken from a hydrant and used to supply water to cattle.
- **Discovered Leaks**. BAAP has a team of maintenance personnel that repair leakage in the process water system that is large enough to be discovered without the aid of a leak detection survey. Approximately 63 leaks were repaired last year, approximately 80% located on main pipelines.
- **Reservoir Evaporation**. The process water system uses an open reservoir for storage. The amount of water that evaporates off the surface of the reservoir was calculated using pan evaporation data from NOAA Technical Report NWS 33 and 34.

The results of the water audit are given on page 5. The amount of recoverable leakage, which is estimated as 75% of the potential water system leakage, was calculated to be 61,707,825 gallons per year. This value represents approximately 52% of the total amount of water pumped from various process water sources; 117,532,000 gallons per year. This figure was obtained from BAAP historical meter data.

The total beneficial value of repairing recoverable leakage was calculated. Beneficial value is calculated by multiplying the amount of leakage saved times the cost of process water. The cost of process water at BAAP is a combination of several factors:

- **Pump Electrical Consumption**. Process water will be pumped into the distribution system primarily by a 500 gpm pump with a 40 hp motor. The pump is located at the Pump & Treat (IRM) Facility. Well No. 4, with a capacity of 935 gpm and a 100 hp motor, supplements the IRM Facility pump during periods of peak demand and maintenance. A reduction of leakage in the process water distribution system would reduce the amount of water that is pumped, thus saving electrical energy consumed by the pumps.
- **Chemical Treatment**. Chlorine is currently fed into the process water system at the source. High quality, bacteria-free water is required for production and domestic uses. Because chlorine is injected per volume of process water pumped, reducing the amount of leakage lost would reduce the amount of chlorine required.

1. COMPONENT ARMY	FY 1995 MILITARY CONSTRUCTION PROJECT DATA	2. DATE May-95
3. INSTALLATION AND LOCATION Badger Army Ammunition Plant; Baraboo, WI		
4. PROJECT TITLE Implement Leak Detection Program		5. PROJECT NUMBER

ECONOMIC ANALYSIS (cont.)

- **Well Maintenance.** Money is annually budgeted to maintain the five wells at BAAP. Two of the wells (No. 4 & 5) are used as sources for the process water system. Decreased operating time for the well pumps will reduce the amount of maintenance required for pumps and pump motors.
- **Distribution Maintenance.** BAAP uses a maintenance crew to repair leakage in the distribution system. If leakage can be reduced in the distribution system, fewer labor hours will be needed to located and repair leakage.

The total beneficial cost of performing a leak detection survey to recover leakage from the process water system was assumed to be only the costs that vary with the amount of water delivered. These include the energy, well maintenance and chemical treatment costs. Distribution maintenance costs were not included because they are budgeted, fixed costs. The cost of leak repair is also not included. Since leaks are continually discovered and repaired in the normal course of operations, the leaks found in the leak detection program would be repaired eventually. If the leaks are repaired as part of a leak detection program, as is BAAP's policy, BAAP avoids the expense of repairing leaks as they are accidentally discovered. Although some cost savings would be realized in fixing the leaks when they are discovered by a leak detection program, as opposed to discovering them accidentally, AWWA Manual 36 allows the auditor to assume that the savings is negligible.

The total payback of the leak detection program was calculated by dividing the total cost of the leak detection program by the cost savings of recovering leakage. The total cost of the leak detection survey was taken from the average cost of previous leak detection surveys at BAAP and from cost information provided by AWWA. The cost of leak detection was given as $150 per mile of pipe surveyed. Approximately 105 miles of piping in the process water system would need to be investigated.

A summary of the water audit, along with the LCCA, is provided on the following pages.

1. COMPONENT ARMY	FY 1995 MILITARY CONSTRUCTION PROJECT DATA	2. DATE May-95

3. INSTALLATION AND LOCATION
Badger Army Ammunition Plant; Baraboo, WI

4. PROJECT TITLE	5. PROJECT NUMBER
BAAP Water Conservation Study	

LIFE CYCLE COST ANALYSIS SUMMARY
ENERGY CONSERVATION INVESTMENT PROGRAM (ECIP)

LOCATION:	Badger Army Ammunition Plant	REGION: 2 (Wisconsin)		PROJECT NO:	1406-004
PROJECT TITLE:	Leak Detection Study			FISCAL YEAR:	1995
ANALYSIS DATE:	05/09/95	ECONOMIC LIFE:	20	PREPARED BY:	T. Poeling

1. INVESTMENT: **ECO #4 - Implement Leak Detection Program After ECO #2 and #3**

A.	CONSTRUCTION COST	=	$15,750	
B.	SIOH COST	(6.0% of 1A) =	$945	
C.	DESIGN COST	(6.0% of 1A) =	$945	
D.	TOTAL COST	(1A +1B +1C) =	$17,640	
E.	SALVAGE VALUE OF EXISTING EQUIPMENT =		$0	
F.	PUBLIC UTILITY COMPANY REBATE =		$0	
G.	TOTAL INVESTMENT	(1D -1E -1F) =	------->	$17,640

2. ENERGY SAVINGS (+) OR COST (-):
DATE OF NISTR 4942-1 USED FOR DISCOUNT FACTORS: BOD Oct 1994

	ENERGY SOURCE	FUEL COST $/KGAL (1)	SAVINGS KGAL/YR (2)	ANNUAL $ SAVINGS (3)	DISCOUNT FACTOR (4)	DISCOUNTED SAVINGS (5)	
A.	ELECT. (CURRENT)	$0.05	61,708	$2,900	15.88	$46,056	
B.	ELECT. (POTENTIAL)	$0.05	0	$0	15.88	$0	
C.	DIST	$5.00	0	$0	19.16	$0	
D.	NAT GAS	$4.00	0	$0	18.30	$0	
E.	COAL	$2.60	0	$0	16.62	$0	
G.	DEMAND (KW)	$6.82	0	$0	14.88	$0	
H.	TOTAL		61,708	$2,900		-------->	$46,056

3. NON-ENERGY SAVINGS (+) OR COST (-)

A. ANNUAL RECURRING (+/-)

1 WELL MAINTENANCE ($0.27/KGAL)	$16,661	14.88	$247,917
2 WATER DIST. MAINTENANCE ($1.22/KGAL)	$0	14.88	$0
3 CHEMICAL TREAT. SAVINGS ($0.032/KGAL)	$1,975	14.88	$29,383
4 TOTAL ANNUAL DISC. SAVINGS (+) / COST (-)	$18,636		$277,300

B. NON-RECURRING (+/-)

ITEM	SAVINGS (+) COST(-) (1)	YEAR OF OCCURRENCE (2)	DISCOUNT FACTOR (3) (TABLE A-2)	DISCOUNTED SAVINGS/ COST (4)
a.	$0		0.000	$0
b.	$0		0.000	$0
c.	$0		0.000	$0
d. TOTAL	$0			$0

C. TOTAL NON-ENERGY DISCOUNTED SAVINGS (+) OR COST (-) (3A4 + 3Bd4) = $277,300

4.	FIRST YEAR DOLLAR SAVINGS (+) / COSTS (-)	(2H3+3A+(3Bd1/Economic Life))	$21,536
5.	SIMPLE PAYBACK (SPB) IN YEARS (MUST BE < 10 YEARS TO QUALIFY)	(1G/4) =	0.82
6.	TOTAL NET DISCOUNTED SAVINGS	(2H5 + 3C) =	$323,356
7.	DISCOUNTED SAVINGS-TO-INVESTMENT RATIO (SIR) (MUST HAVE SIR > 1.25 TO QUALIFY)	(6/1G) =	18.33

1. COMPONENT ARMY	FY 1995 MILITARY CONSTRUCTION PROJECT DATA	2. DATE May-95
3. INSTALLATION AND LOCATION Badger Army Ammunition Plant; Baraboo, WI		
4. PROJECT TITLE BAAP Water Conservation Study	5. PROJECT NUMBER	

WATER AUDIT

Total Amount of Water Pumped (metered):		250,900,000
Leakage Saved by Relining Pipes (ECO #2)		54,636,000
Leakage Saved by Isolating "Caretaker" Area (ECO #3)		18,732,000
Net Water Pumped after ECO Implementation:		177,532,000
Unmetered Water Uses (Provided by BAAP):		
Fire hydrant exercising:	2000 gpm x 10 min x 675 hydrants	13,500,000
Industrial uses:		
Boilers	32,000,000 lbs/yr x 1,198 gals/lb	3,900,000
Cooling Water	40 gpm x 1,440 min/day x 365 days/yr	21,100,000
Domestic Water	525,000 gals/month x 12 months/yr	6,300,000
Maintenance Activities	20 gpm x 60 min/hr x 10 hrs/day x 4 days/wk x 52 weeks/year	2,500,000
Irrigation (Cattle)	400,000 gals/month x 6 months	2,400,000
Discovered Leaks (by maintenance personnel, not leak detection survey):		
Main water breaks	50 breaks x 20 gpm x 1,440 min/day x 30 days	43,200,000
Service laterals & valves	13 breaks x 2 gpm x 1,440 min/day x 30 days	1,123,200
Reservoir Evaporation (calculated value)		1,231,700
Total Identified Water Losses:		**95,254,900**
Potential Water System Leakage:		**82,277,100**
Recoverable Leakage (AWWA Manual 36 estimates 75% is recoverable):		**61,707,825**
Cost of Water Supply (per 1000 gallons):	$0.05 pumping costs, $0.032 chemical treatment $0.27 well maintenance costs	**$0.349**
One Year Benefit from Recoverable Leakage:		**$21,536**
Total Cost of Leak Detection Program:	$150 / mile x 105 miles + 6% SIOH +6% Design	**$17,640**
Simple Payback (years):		**0.82**

PREVIOUS EDITIONS MAY BE USED INTERNALLY UNTIL EXHAUSTED

DD FORM 1391C
1 DEC 76

FOR OFFICIAL USE ONLY *(WHEN DATA IS ENTERED)*

 (Taken From AWWA Manual 36)

WATER AUDIT WORKSHEET

For: Badger Army Ammunition Plant Audit Study Period: Avg. Year

Line	Item	Water Volume: Subtotal	Water Volume: Total Cumulative	Water Volume: Units*
Task 1—Measure Supply				
1	Uncorrected total water supply to the distribution system (total of master meters)		177,532,000	gal/yr.
2A-C	Adjustments to total water supply			
2A	Source meter error (+ or –)	–		
2B	Change in reservoir and tank storage (+ or –)	–		
2C	Other contributions or losses (+ or –)	–		
3	Total adjustments to total water supply (add lines 2A, 2B, and 2C)	–		
4	Adjusted total water supply to the distribution system (add line 1 and line 3)		177,532,000	gal/yr.
Task 2—Measure Metered Use				
5	Uncorrected total metered water use	–		
6	Adjustments due to meter reading lag time (+ or –)	–		
7	Metered deliveries (add lines 5 and 6)	–		
8A-C	Total sales meter error and system-service meter errors (+ or –)			
8A	Residential meter error	–		
8B	Large meter error	–		
8C	Total (add line 8A and 8B)	–		
9	Corrected total metered water deliveries (add lines 7 and 8C)	–		
10	Corrected total unmetered water (subtract line 9 from line 4)		177,532,000	gal/yr.
11A-M	Authorized unmetered water uses			
11A	Firefighting and firefighting training	13,500,000		gal/yr.
11B	Main flushing			

NOTE: 1 ac-ft = 43,560 ft^3 = 325,851 gal.

*Units of measure must be consistent throughout the worksheet. The particular unit used (that is, acre-feet, millions of gallons, cubic feet, cubic metres, or other unit) is left to the user.

Form continues on next page.

Line	Item	Water Volume: Subtotal	Water Volume: Total Cumulative	Water Volume: Units*
11A-M	Authorized unmetered water uses (continued)			
11C	Storm drain flushing	–		
11D	Sewer cleaning	–		
11E	Street cleaning	–		
11F	Schools	–		
11G	Landscaping in large public areas:			
	Parks	–		
	Golf courses	–		
	Cemeteries	–		
	Playgrounds	–		
	Highway median strips	–		
	Other landscaping	–		
11H	Decorative water facilities	–		
11I	Swimming pools	–		
11J	Construction sites			
11K	Water quality and other testing (pressure testing pipe, water quality, etc.)	–		
11L	Process water at ~~treatment plants~~ industrial uses	33,500,000		gal/yr.
11M	Other unmetered uses (irrigation)	2,400,000		gal/yr.
12	Total authorized unmetered water (add lines 11A through 11M)		49,700,000	gal/yr.
13	Total water losses (subtract line 12 from line 10)		127,832,000	gal/yr.
14A-H	Identified water losses			
14A	Accounting procedure errors	–		
14B	Illegal connections	–		
14C	Malfunctioning distribution system controls	–		
14D	Reservoir seepage and leakage	–		
14E	Evaporation	1,231,700		gal/yr.

NOTE: 1 ac-ft = 43,560 ft^3 = 325,851 gal.

*Units of measure must be consistent throughout the worksheet. The particular unit used (that is, acre-feet, millions of gallons, cubic feet, cubic metres, or other unit) is left to the user.

Form continues on next page.

Line	Item	Water Volume: Subtotal	Water Volume: Total Cumulative	Water Volume: Units*
14A-H	Identified water losses (continued)			
14F	Reservoir overflow	–		
14G	Discovered leaks	44,323,200		gal/yr.
14H	Theft			
15	Total identified water losses (add lines 14A through 14H)	45,554,906		gal/yr.
16	Potential water system leakage (subtract line 15 from line 13)		82,277,100	gal/yr.
17	Recoverable leakage (multiply line 16 by 0.75)		61,707,825	gal/yr.

Line	Item	Dollars per Unit of Volume
18A-B	Cost savings	
18A	Cost of water supply	$0.047/1000 gal (Pumping cost)
18B	Variable operation and maintenance costs	$0.302/1000 gal (Chemical, well cost)
19	Total costs per unit of recoverable leakage (add line 18A and line 18B)	$0.349/1000 gal

Line	Item	Dollars per Year
20	One-year benefit from recoverable leakage (multiply line 17 by line 19)	$21,536
21	Total benefits from recovered leakage (multiply line 20 by 2)	$43,072
22	Total costs of leak detection project	$17,640
23	Benefit to cost ratio (divide line 21 by line 22)	2.44

Prepared by:

Name Tom Poeling

Title EMC Engineers, Inc. Date 4/20/95

NOTE: 1 ac-ft = 43,560 ft^3 = 325,851 gal.

*Units of measure must be consistent throughout the worksheet. The particular unit used (that is, acre-feet, millions of gallons, cubic feet, cubic metres, or other unit) is left to the user.

FACSIMILE TRANSMITTAL

olin
ORDNANCE

BADGER ARMY AMMUNITION PLANT

BARABOO, WISCONSIN
FAX: (608) 643-2674
TEL: (608) 643-3361

TO: Tom Poeling DATE: 20 April 1995

COMPANY: EMC Engineers

FACSIMILE PHONE NO: (303) 985-2527

FROM: Randy Sprecher

SUBJECT: Water Usage Data

ADDITIONAL INFORMATION: Attached is estimated annual water usage and water main repairs - as per your request.

Map showing mains to be given highest priority for relining will be mailed.

Concur with Confirmation Notices 2 & 3. No additional comments.

Thanks,

Randy Sprecher

WE ARE TRANSMITTING 1 PAGES IN ADDITION TO THIS COVER SHEET

Water Usage Data

1) Agricultural Usage - Grazing & Irrigation

Use 400,000 gals/mo x 6 mos = 2,400,000 gals/yr.

2) Hydrant Flushing

675 hydrants x 2,000 gpm x 10 min. = 13,500,000 gals/yr.

3) Process Water

a) Boilers 32,000,000 lbs/yr x 1,198 gals/lb = 3,900,000 gals/yr.

b) Cooling Wtr. 40 gpm x 60 min/hr x 24 hr/day x 365 days/yr. = 21,100,000 gals/yr.

c) Domestic Wtr. 525,000 gals/mo x 12 mos/yr = 6,300,000 gals/yr.

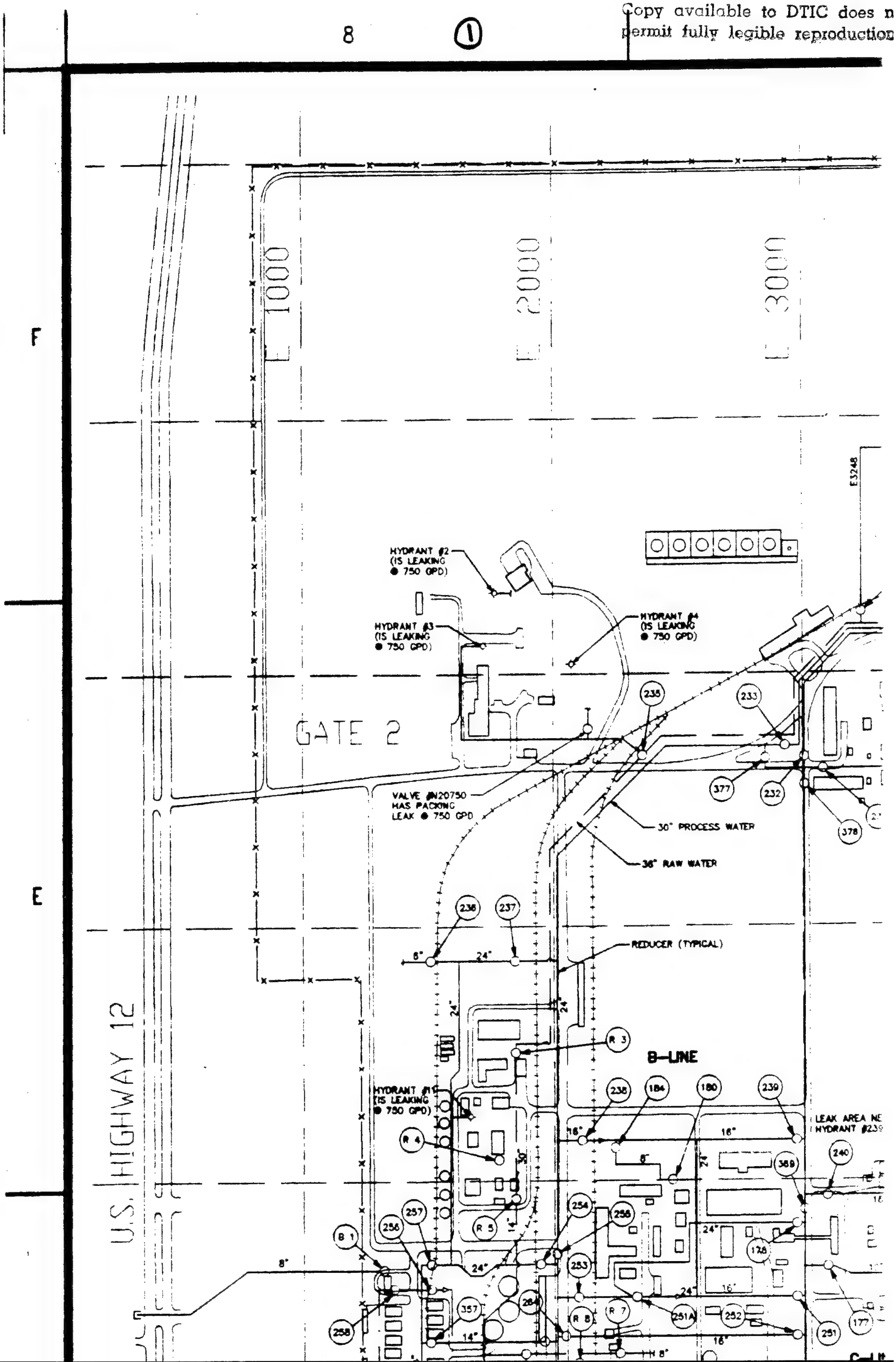
d) Maintenance Activities

20 gpm x 60 min/hr x 10 hrs/day x 4 days/wk x 52 wks/yr. = 2,500,000

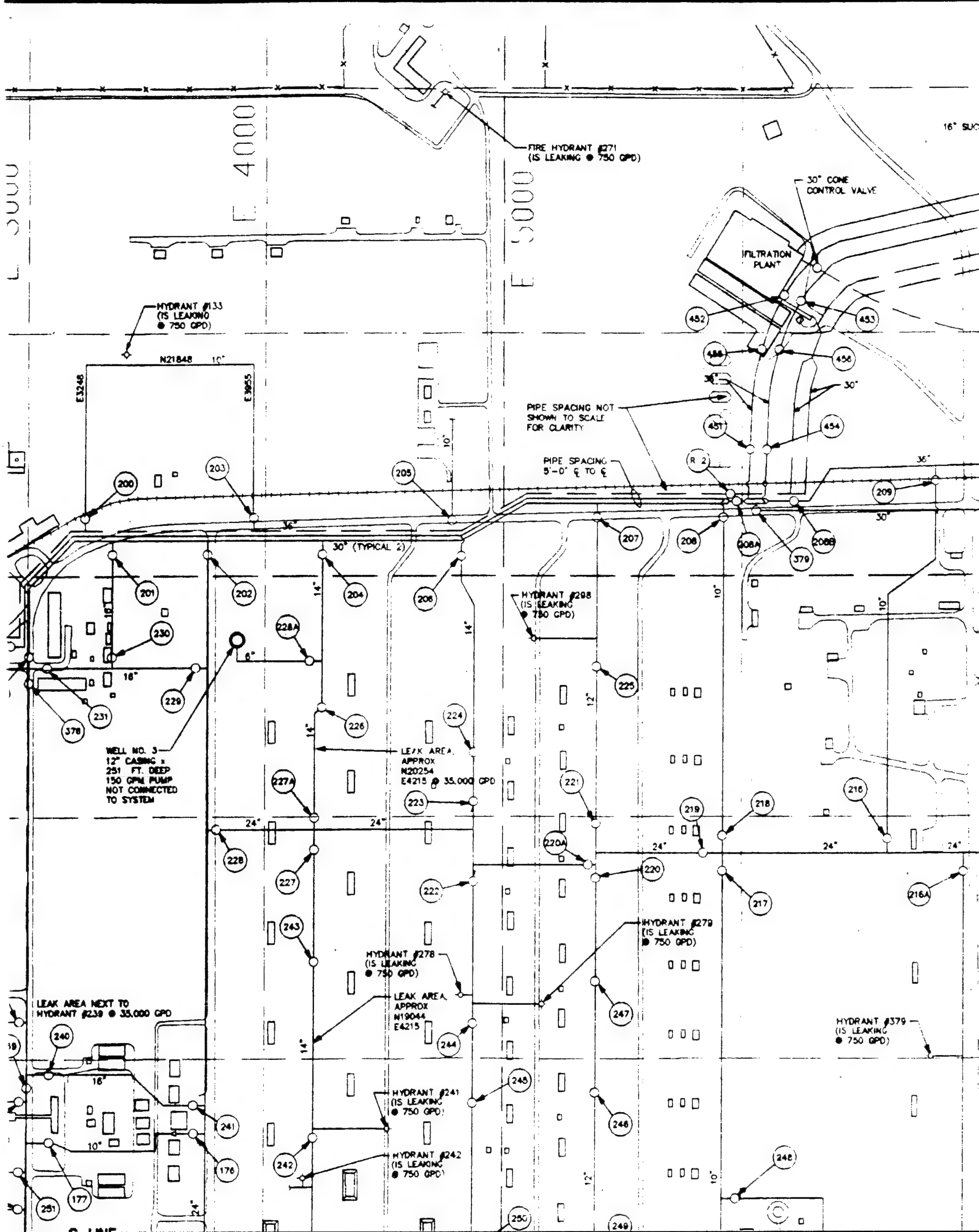
e) Total = 33,800,00 gals/yr.

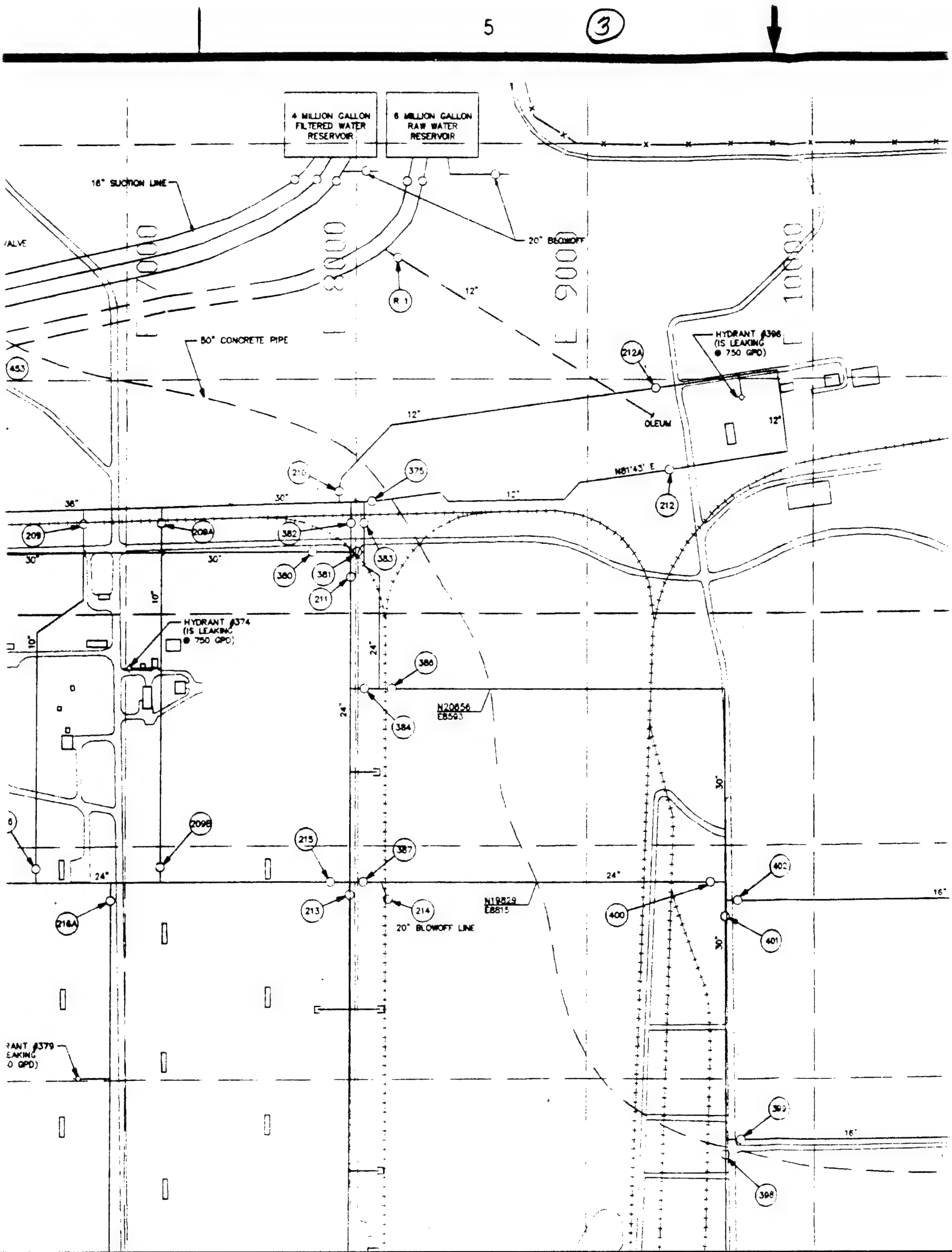
4) Leakage

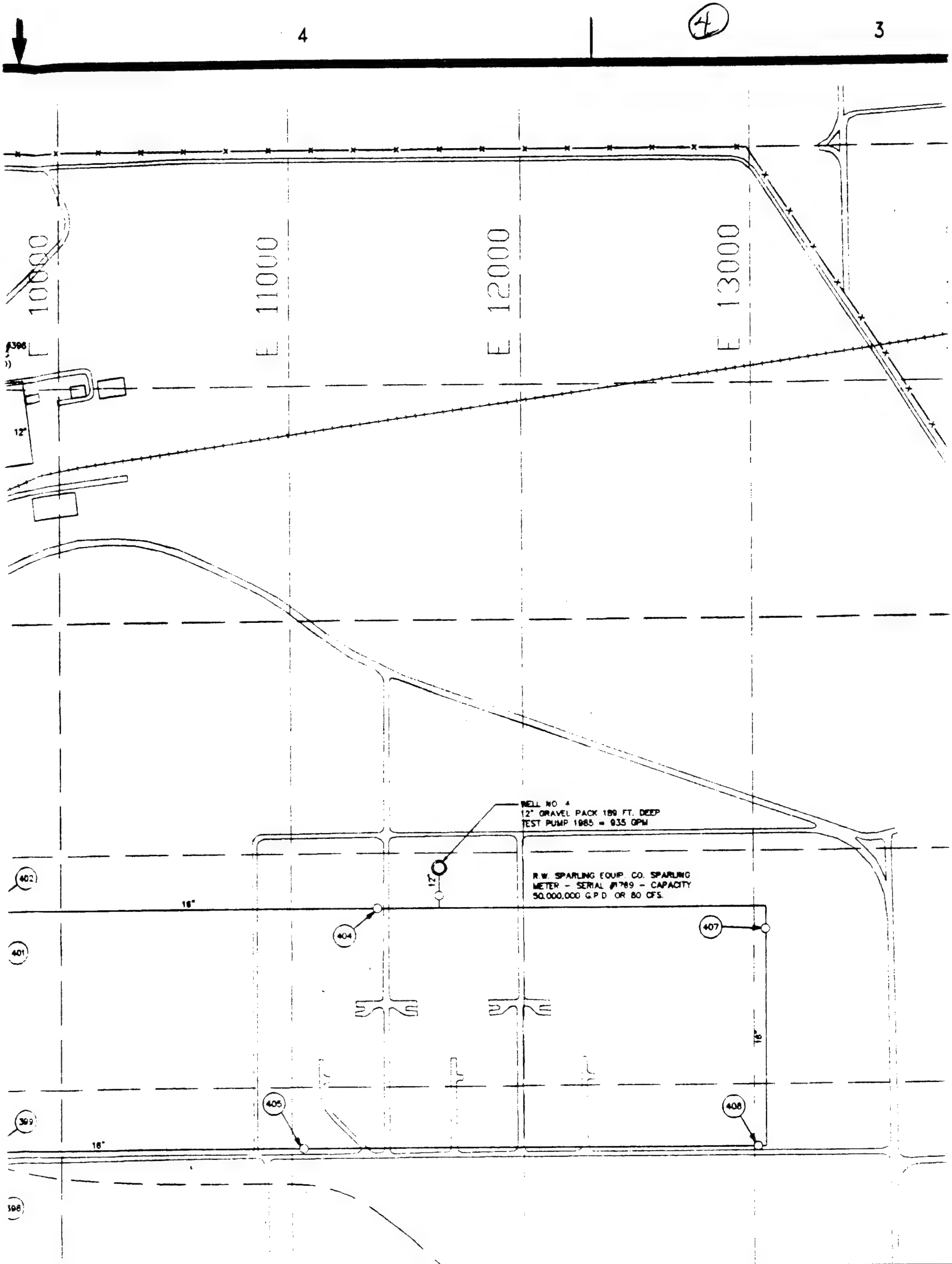
63 water breaks repaired each year. 80% of these are on mains - remainder on service laterials and valves.


8
1
F
E
E 1000
E 2000
E 3000
E3248
HYDRANT #2
(IS LEAKING
@ 750 GPD)
HYDRANT #3
(IS LEAKING
@ 750 GPD)
HYDRANT #4
(IS LEAKING
@ 750 GPD)
GATE 2
VALVE #N20750
HAS PACKING
LEAK @ 750 GPD
30" PROCESS WATER
36" RAW WATER
REDUCER (TYPICAL)
B-LINE
HYDRANT #1
(IS LEAKING
@ 750 GPD)
LEAK AREA NE
HYDRANT #239
U.S. HIGHWAY 12
235
233
377
232
378
236
237
R 3
238
184
180
239
240
389
R 4
R 5
257
256
B 1
254
255
253
178
177
357
264
R 8
R 7
251A
252
251
258
24"
8"
16"
18"
30"
14"

7 (2) 6

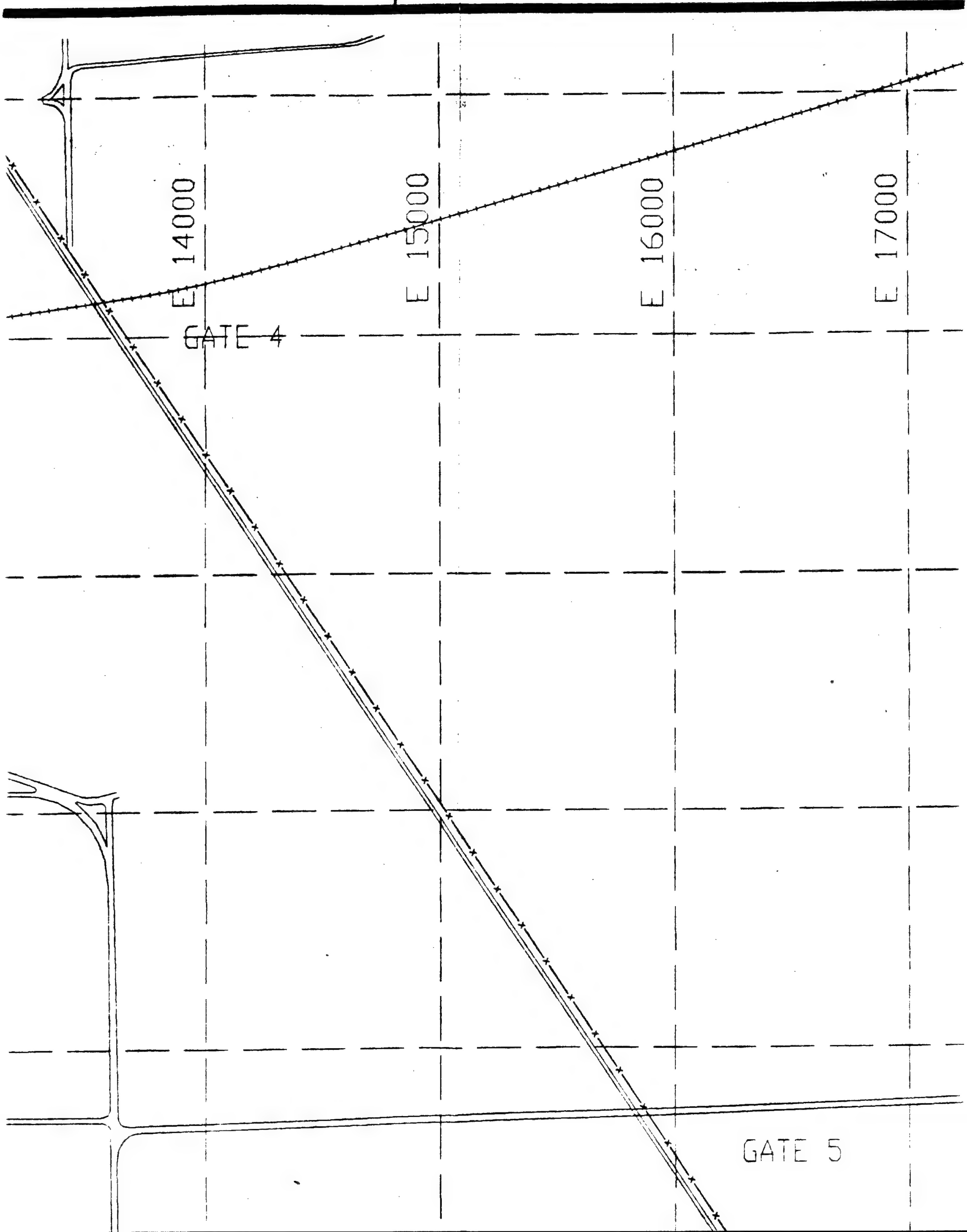

FIRE HYDRANT #271
(IS LEAKING @ 750 GPD)
E 4000
E 5000
16" SUCT
30" CONE
CONTROL VALVE
FILTRATION
PLANT
HYDRANT #133
(IS LEAKING
@ 750 GPD)
N21848
10"
E3248
E3955
452
453
455
456
36"
30"
PIPE SPACING NOT
SHOWN TO SCALE
FOR CLARITY
451
454
PIPE SPACING
5'-0" ℄ TO ℄
R 2
36"
30"
200
203
205
209
36"
30" (TYPICAL 2)
207
208
208A
379
208B
201
202
204
206
HYDRANT #298
(IS LEAKING
@ 750 GPD)
230
228A
6"
16"
229
231
378
225
224
226
WELL NO. 3
12" CASING x
251 FT. DEEP
150 GPM PUMP
NOT CONNECTED
TO SYSTEM
LEAK AREA
APPROX
N20254
E4215 @ 35,000 GPD
227A
223
221
216
219
218
24"
228
220A
220
227
222
217
216A
243
HYDRANT #279
(IS LEAKING
@ 750 GPD)
HYDRANT #278
(IS LEAKING
@ 750 GPD)
LEAK AREA
APPROX
N19044
E4215
LEAK AREA NEXT TO
HYDRANT #239 @ 35,000 GPD
240
247
244
HYDRANT #379
(IS LEAKING
@ 750 GPD)
245
HYDRANT #241
(IS LEAKING
@ 750 GPD)
241
246
176
242
HYDRANT #242
(IS LEAKING
@ 750 GPD)
248
177
251
250
249
14"
12"
10"


5
3
4 MILLION GALLON FILTERED WATER RESERVOIR
6 MILLION GALLON RAW WATER RESERVOIR
16" SUCTION LINE
VALVE
20" BLOWOFF
17000
18000
19000
10000
R 1
12"
80" CONCRETE PIPE
453
212A
HYDRANT #396 (IS LEAKING @ 750 GPD)
OLEUM
12"
12"
N81°43' E
210
375
212
36"
30"
12"
209
208A
382
383
30"
30"
380
381
211
10"
HYDRANT #374 (IS LEAKING @ 750 GPD)
10"
24"
386
384
24"
N20656
E8593
30"
209B
215
387
402
24"
24"
16"
216A
213
214
N19829
E8815
400
401
20" BLOWOFF LINE
30"
RANT #379
EAKING
0 GPD)
399
16"
398

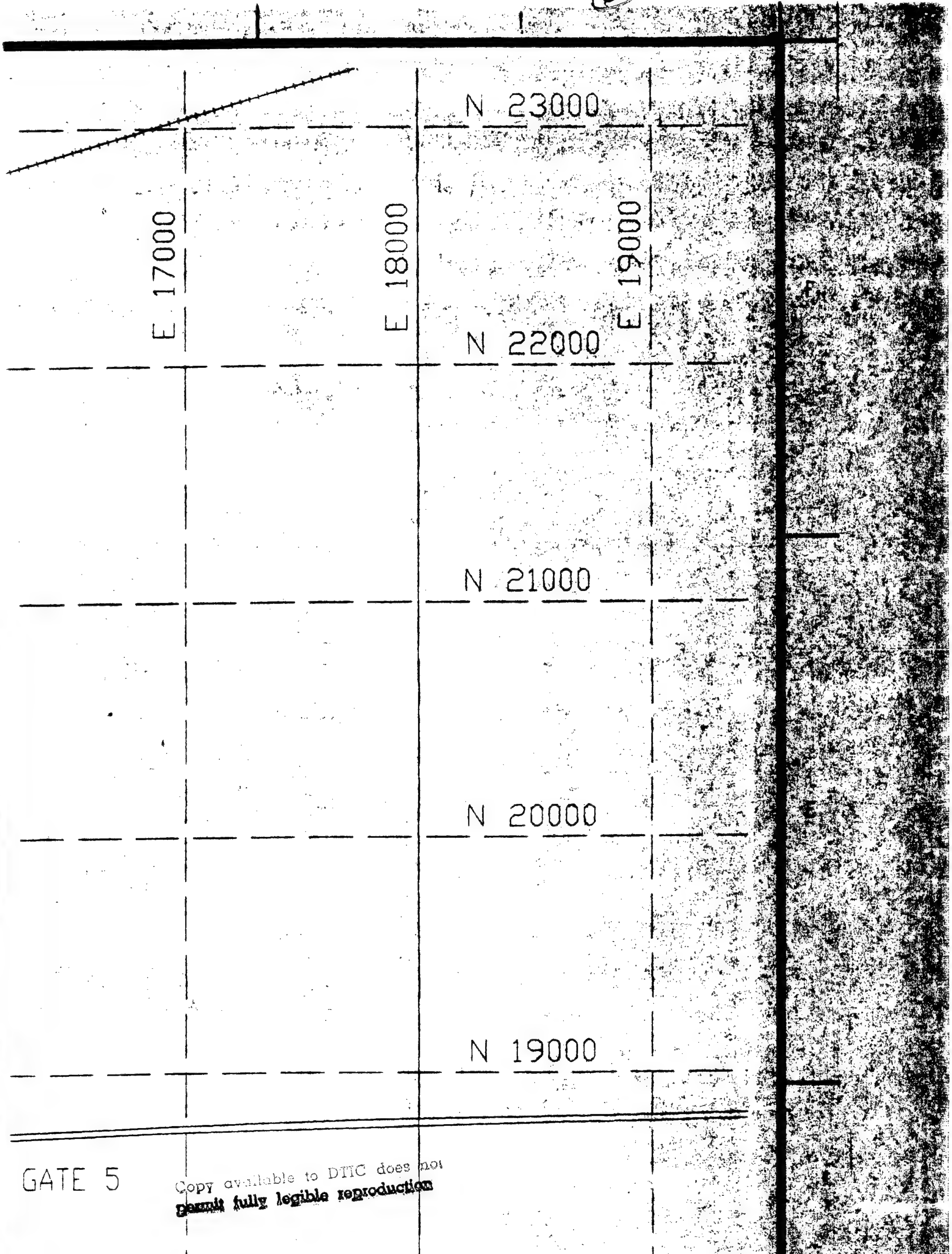


4
4
3
E 10000
E 11000
E 12000
E 13000
396
12"
WELL NO. 4
12" GRAVEL PACK 189 FT. DEEP
TEST PUMP 1985 = 935 GPM
R.W. SPARLING EQUIP. CO. SPARLING
METER - SERIAL #1789 - CAPACITY
50,000,000 G.P.D. OR 80 CFS.
402
401
404
407
16"
12"
18"
399
405
408
16"
398

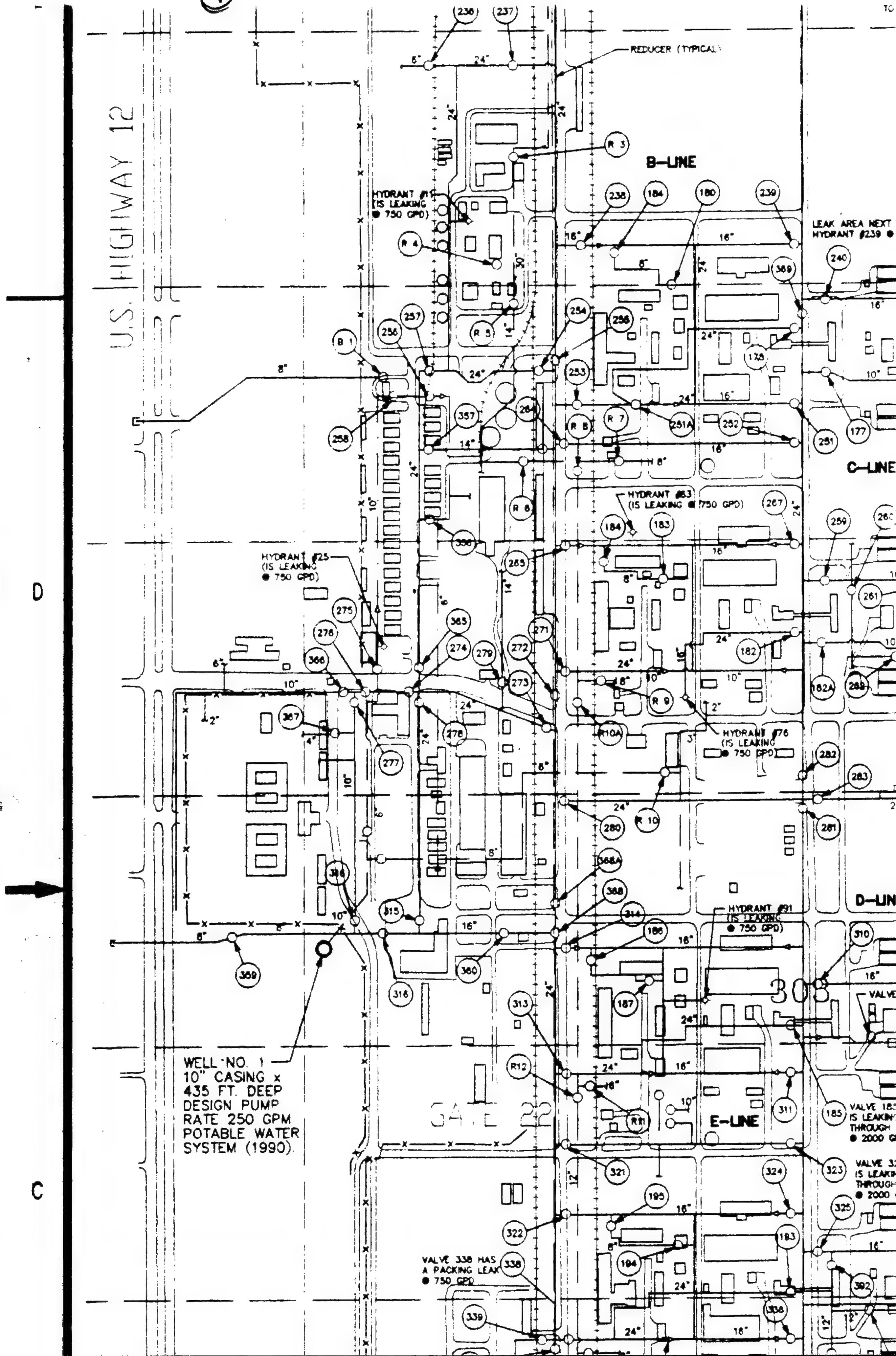
3 2 (5)



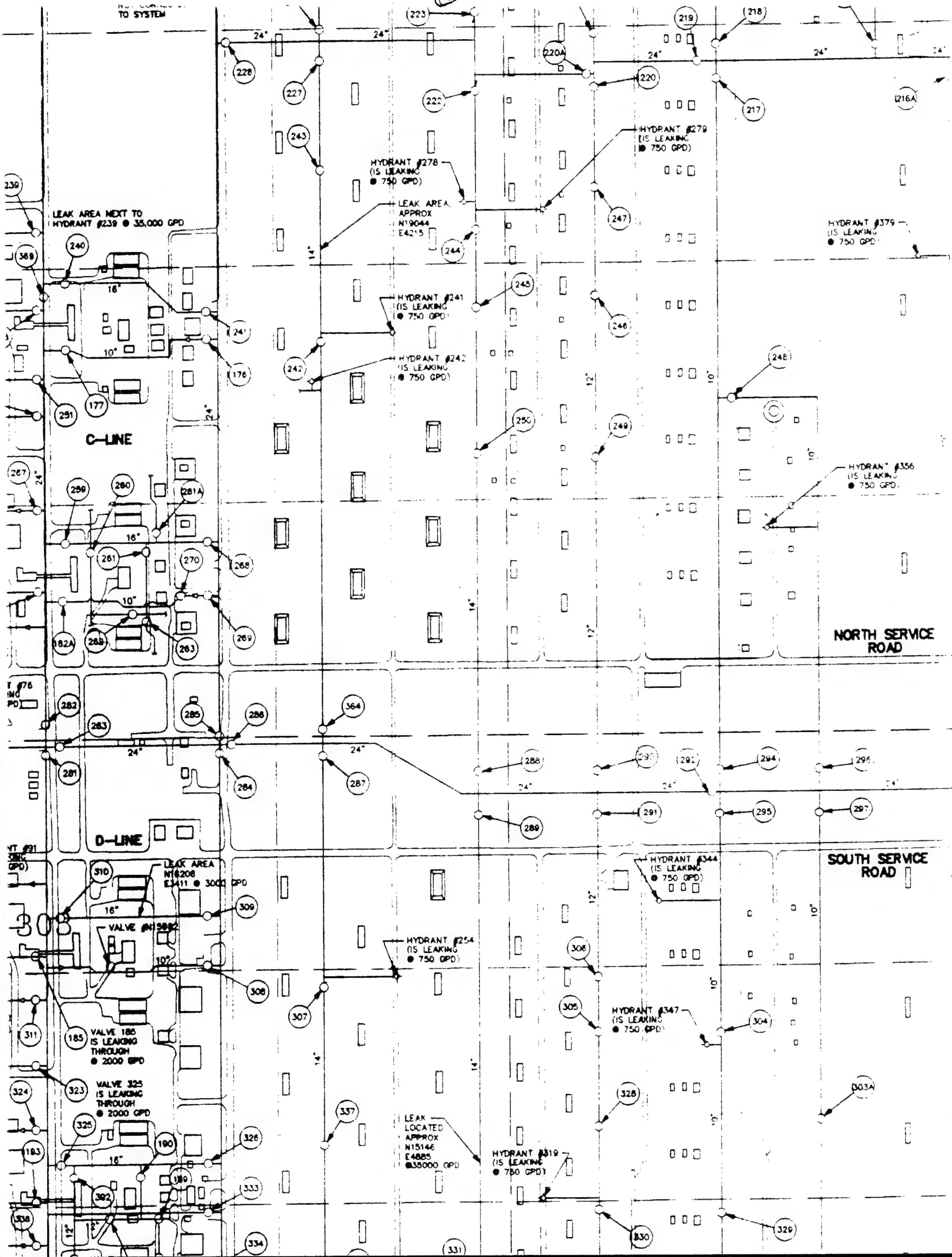
(6)

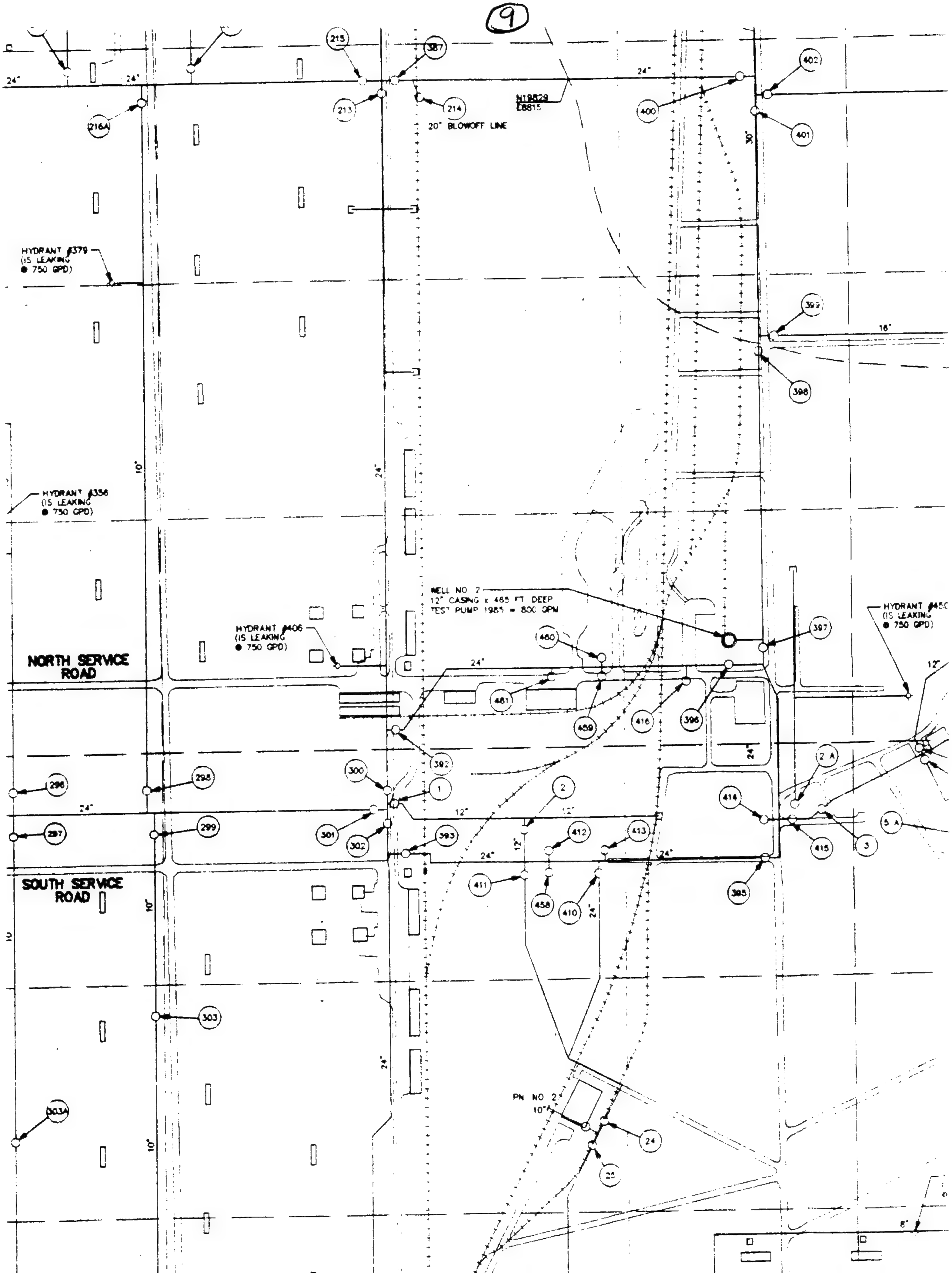

N 23000
E 17000
E 18000
E 19000
N 22000
N 21000
N 20000
N 19000
GATE 5

7

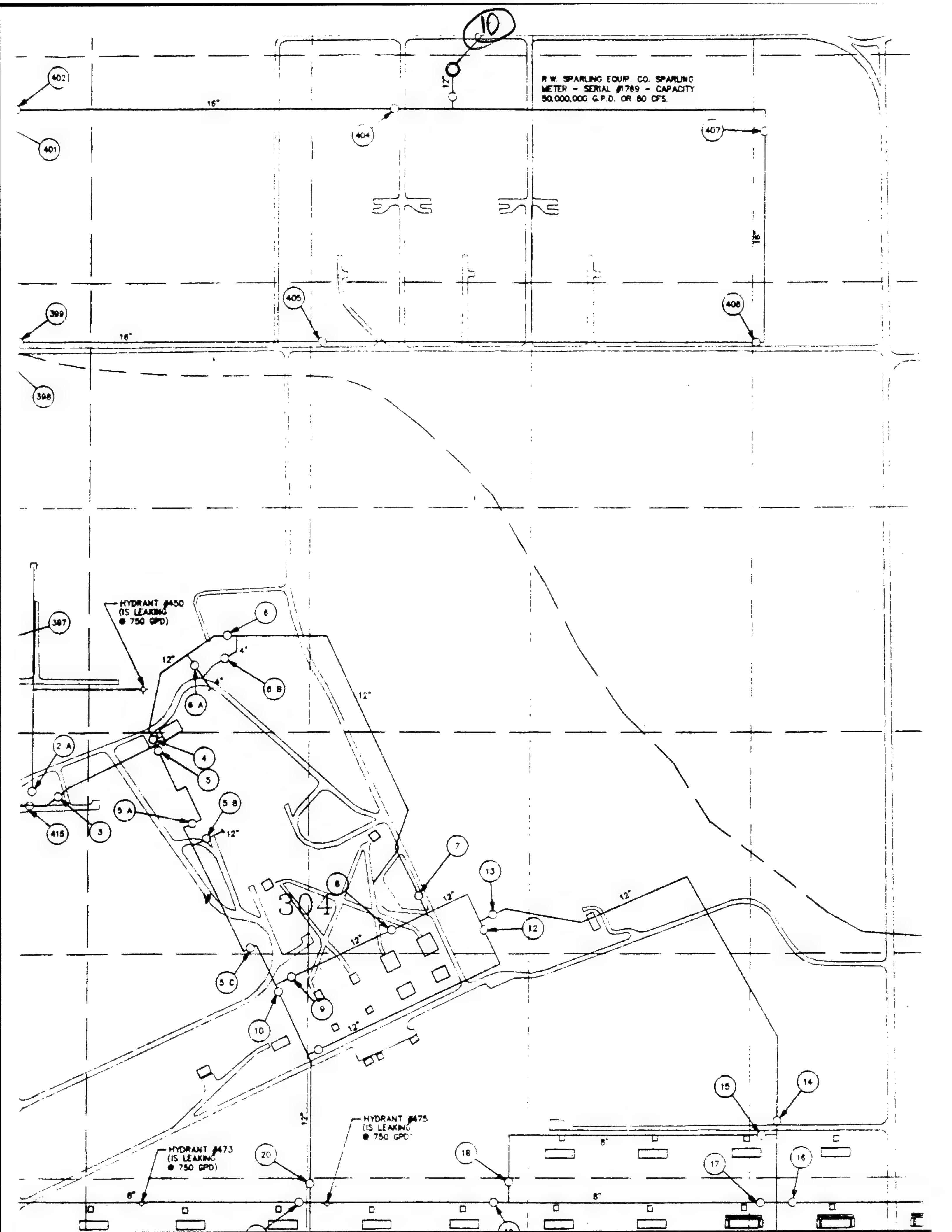

U.S. HIGHWAY 12
REDUCER (TYPICAL)
B-LINE
C-LINE
D-LINE
E-LINE
HYDRANT #11 (IS LEAKING @ 750 GPD)
LEAK AREA NEXT TO HYDRANT #239
HYDRANT #63 (IS LEAKING @ 750 GPD)
HYDRANT #25 (IS LEAKING @ 750 GPD)
HYDRANT #76 (IS LEAKING @ 750 GPD)
HYDRANT #91 (IS LEAKING @ 750 GPD)
WELL NO. 1 10" CASING x 435 FT. DEEP DESIGN PUMP RATE 250 GPM POTABLE WATER SYSTEM (1990)
GATE 22
VALVE 338 HAS A PACKING LEAK @ 750 GPD
D
C

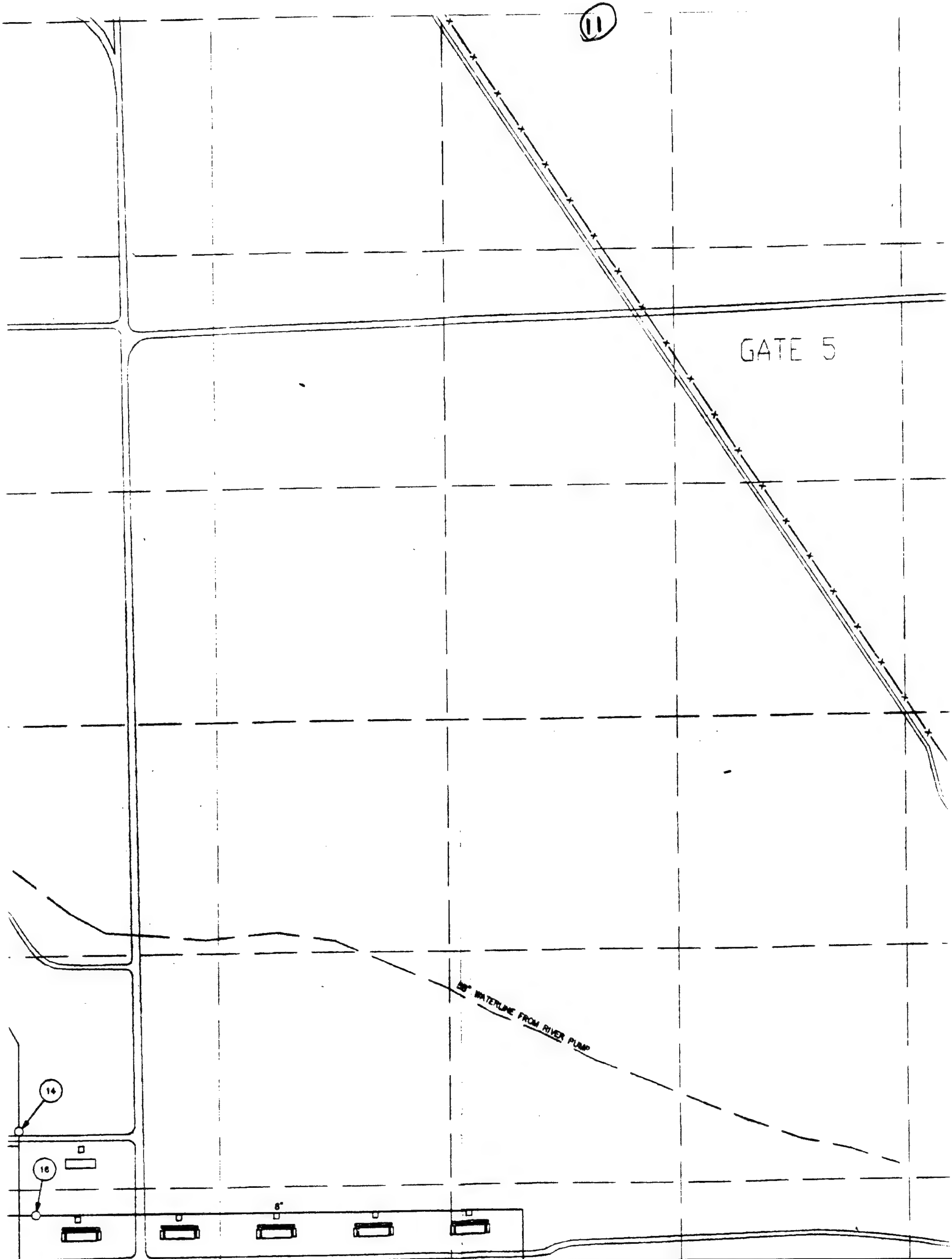
8


TO SYSTEM
LEAK AREA NEXT TO HYDRANT #239 @ 35,000 GPD
HYDRANT #278 (IS LEAKING @ 750 GPD)
HYDRANT #279 (IS LEAKING @ 750 GPD)
LEAK AREA APPROX N19044 E4215
HYDRANT #379 (IS LEAKING @ 750 GPD)
HYDRANT #241 (IS LEAKING @ 750 GPD)
HYDRANT #242 (IS LEAKING @ 750 GPD)
C-LINE
HYDRANT #356 (IS LEAKING @ 750 GPD)
NORTH SERVICE ROAD
D-LINE
LEAK AREA N16208 E3411 @ 3000 GPD
HYDRANT #344 (IS LEAKING @ 750 GPD)
SOUTH SERVICE ROAD
HYDRANT #254 (IS LEAKING @ 750 GPD)
HYDRANT #347 (IS LEAKING @ 750 GPD)
VALVE 185 IS LEAKING THROUGH @ 2000 GPD
VALVE 325 IS LEAKING THROUGH @ 2000 GPD
LEAK LOCATED APPROX N15146 E4885 @35000 GPD
HYDRANT #319 (IS LEAKING @ 750 GPD)
C-LINE
D-LINE

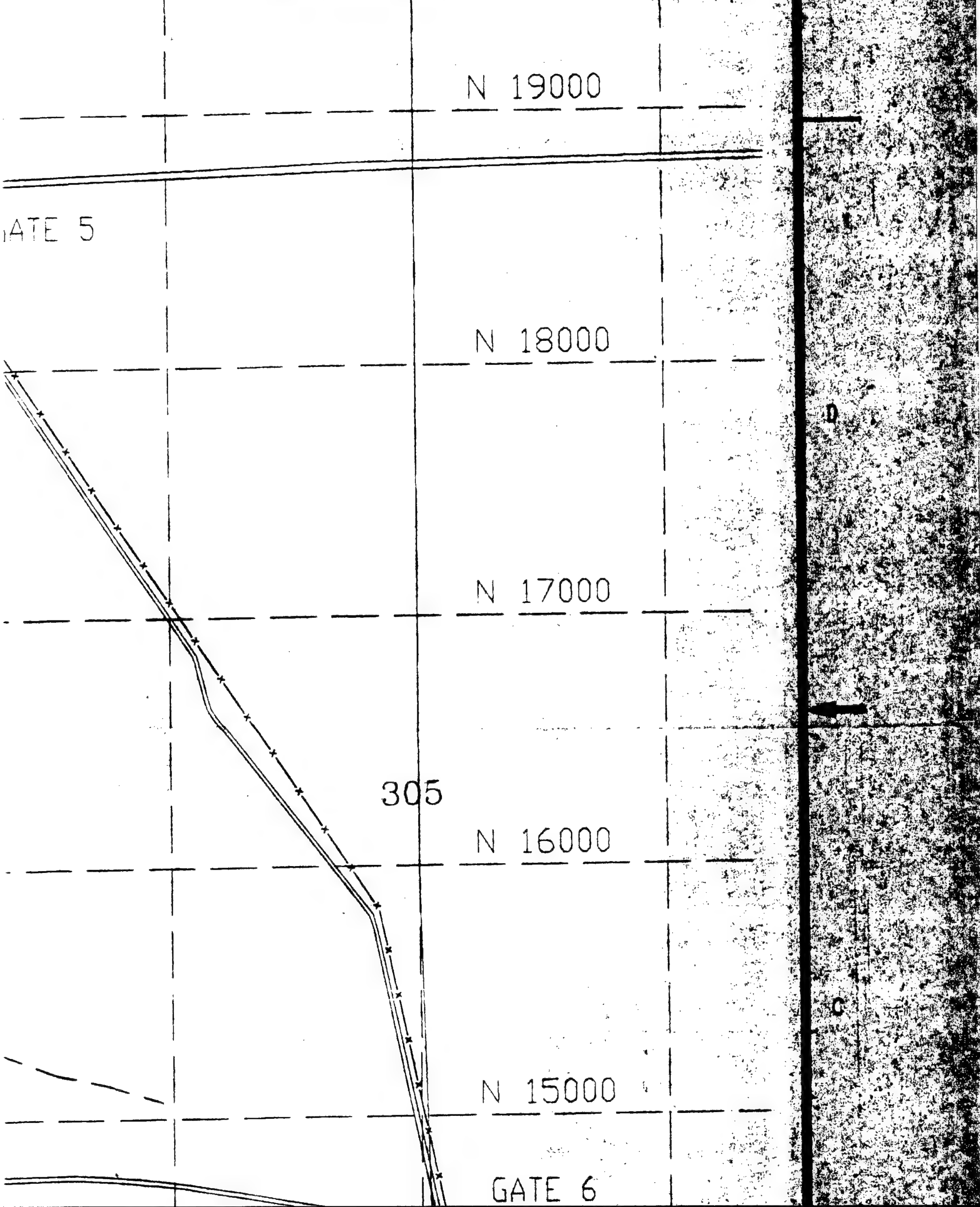


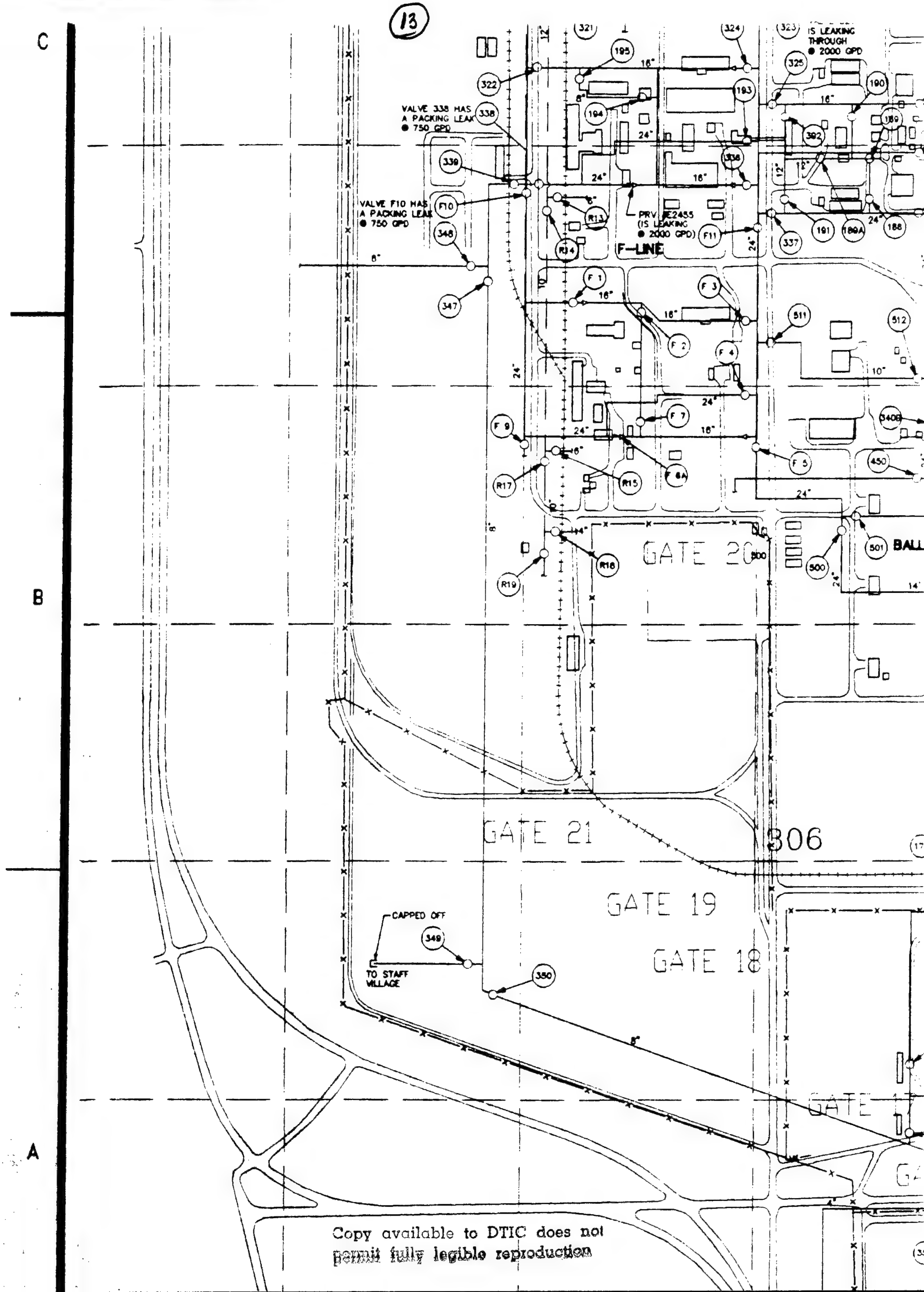
9
HYDRANT #379
(IS LEAKING
● 750 GPD)
HYDRANT #356
(IS LEAKING
● 750 GPD)
HYDRANT #406
(IS LEAKING
● 750 GPD)
HYDRANT #450
(IS LEAKING
● 750 GPD)
NORTH SERVICE ROAD
SOUTH SERVICE ROAD
20" BLOWOFF LINE
N19829
E8815
WELL NO. 2
12" CASING x 465 FT. DEEP
TEST PUMP 1985 = 800 GPM
PN NO. 2


10
R.W. SPARLING EQUIP. CO. SPARLING METER - SERIAL #1769 - CAPACITY 50,000,000 G.P.D. OR 80 CFS.
402
401
404
407
16"
12"
399
398
405
408
397
HYDRANT #450 (IS LEAKING @ 750 GPD)
6
6 A
6 B
4"
2 A
4
5
5 A
5 B
3
415
7
8
13
12
304
5 C
9
10
14
15
HYDRANT #475 (IS LEAKING @ 750 GPD)
HYDRANT #473 (IS LEAKING @ 750 GPD)
20
18
17
16
8"

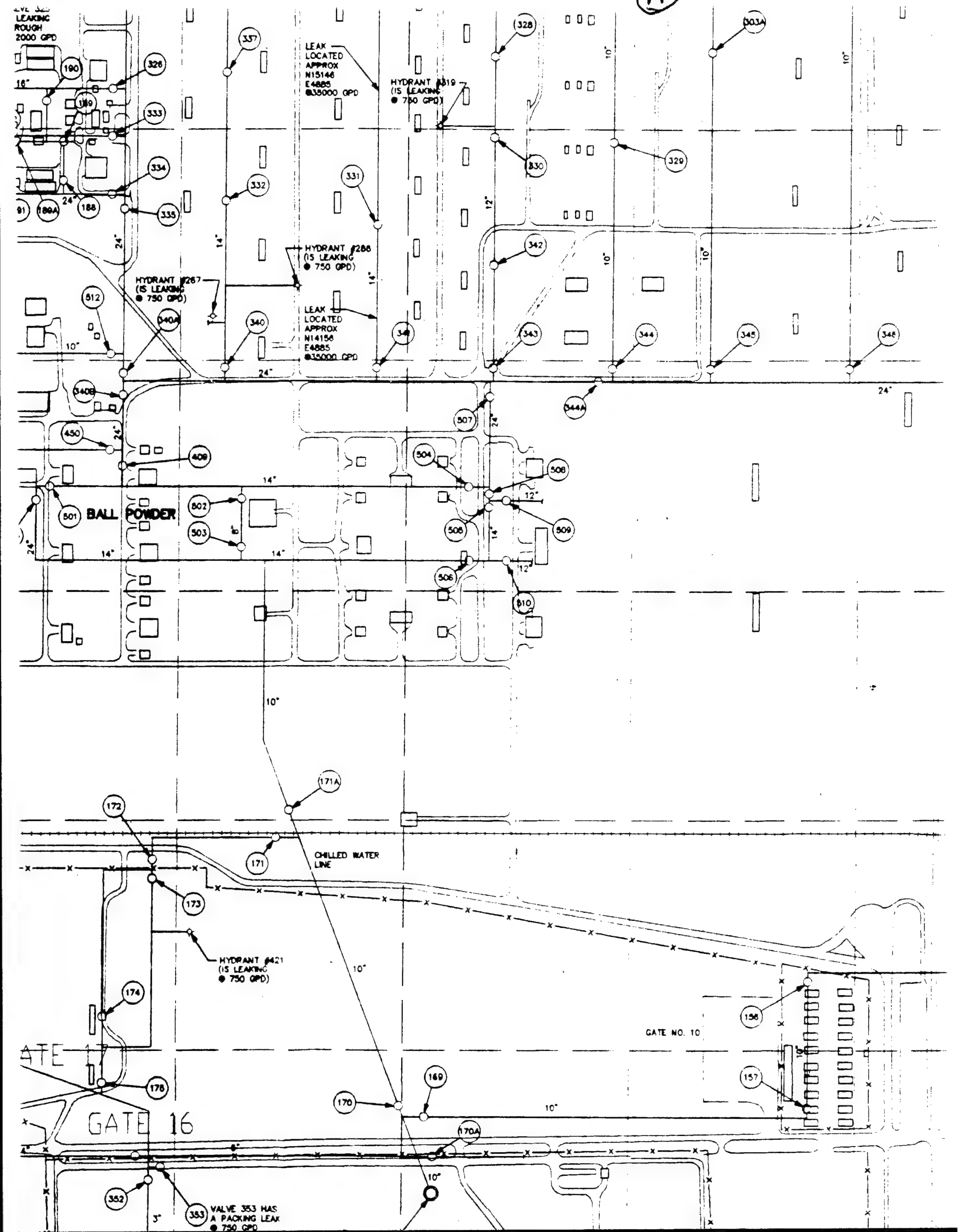

11
GATE 5
WATERLINE FROM RIVER PUMP
14
16
8"

(12)

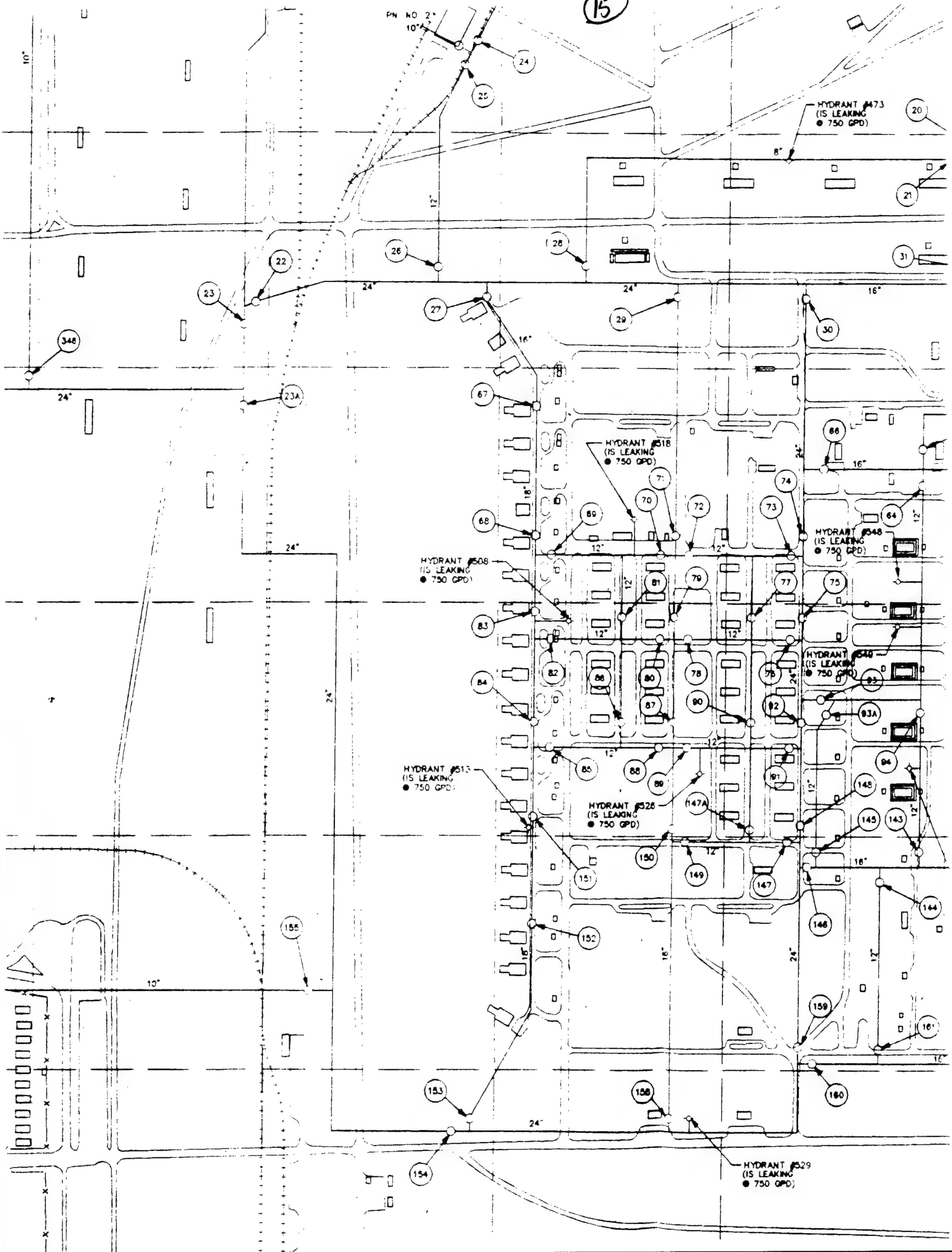



13
C
B
A
VALVE 338 HAS A PACKING LEAK ● 750 GPD
VALVE F10 HAS A PACKING LEAK ● 750 GPD
IS LEAKING THROUGH ● 2000 GPD
PRV RE2455 (IS LEAKING ● 2000 GPD)
F-LINE
GATE 20
GATE 21
306
GATE 19
GATE 18
GATE 17
BALL
CAPPED OFF
TO STAFF VILLAGE
321
324
323
195
322
193
325
190
194
338
189
392
339
336
F10
R13
F11
191
189A
188
337
348
R14
347
F 1
F 3
511
512
F 2
F 4
F 7
340B
F 9
F 5
450
R17
R15
F 6A
R18
R19
500
501
349
350
16"
24"
12"
8"
10"
14"

14

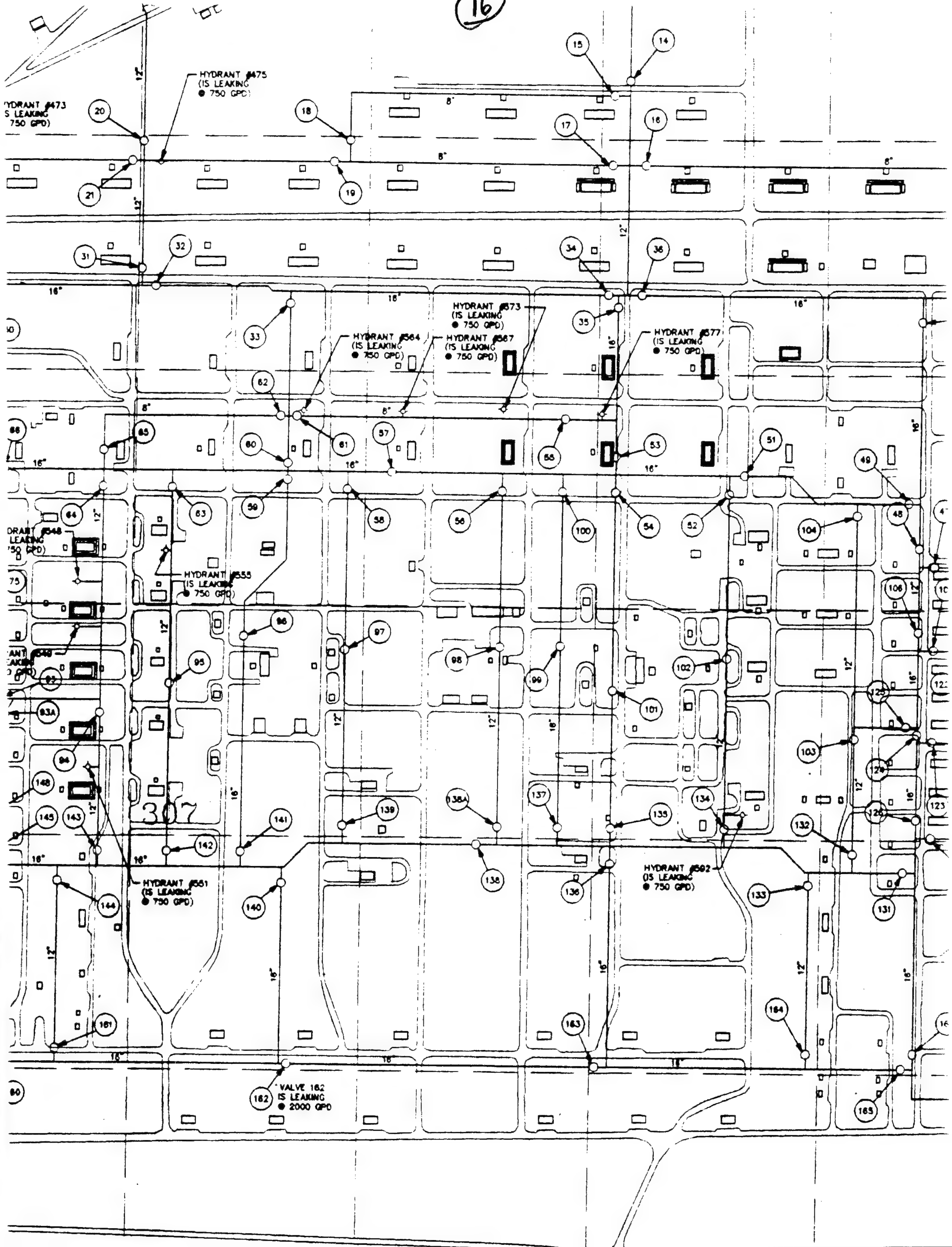

LEAKING
ROUGH
2000 GPD
LEAK
LOCATED
APPROX
N15146
E4885
@35000 GPD
HYDRANT #319
(IS LEAKING
● 750 GPD)
HYDRANT #288
(IS LEAKING
● 750 GPD)
HYDRANT #267
(IS LEAKING
● 750 GPD)
LEAK
LOCATED
APPROX
N14156
E4885
@35000 GPD
BALL POWDER
CHILLED WATER
LINE
HYDRANT #421
(IS LEAKING
● 750 GPD)
GATE NO. 10
GATE 16
VALVE 353 HAS
A PACKING LEAK
● 750 GPD
190
326
189
333
334
188
189A
335
337
332
331
328
303A
330
329
342
512
340A
340
341
343
344
345
346
340B
344A
507
450
409
504
508
501
502
503
509
506
510
171A
172
171
173
174
176
156
157
169
170
170A
352
353
24"
14"
10"
12"
16"
3"

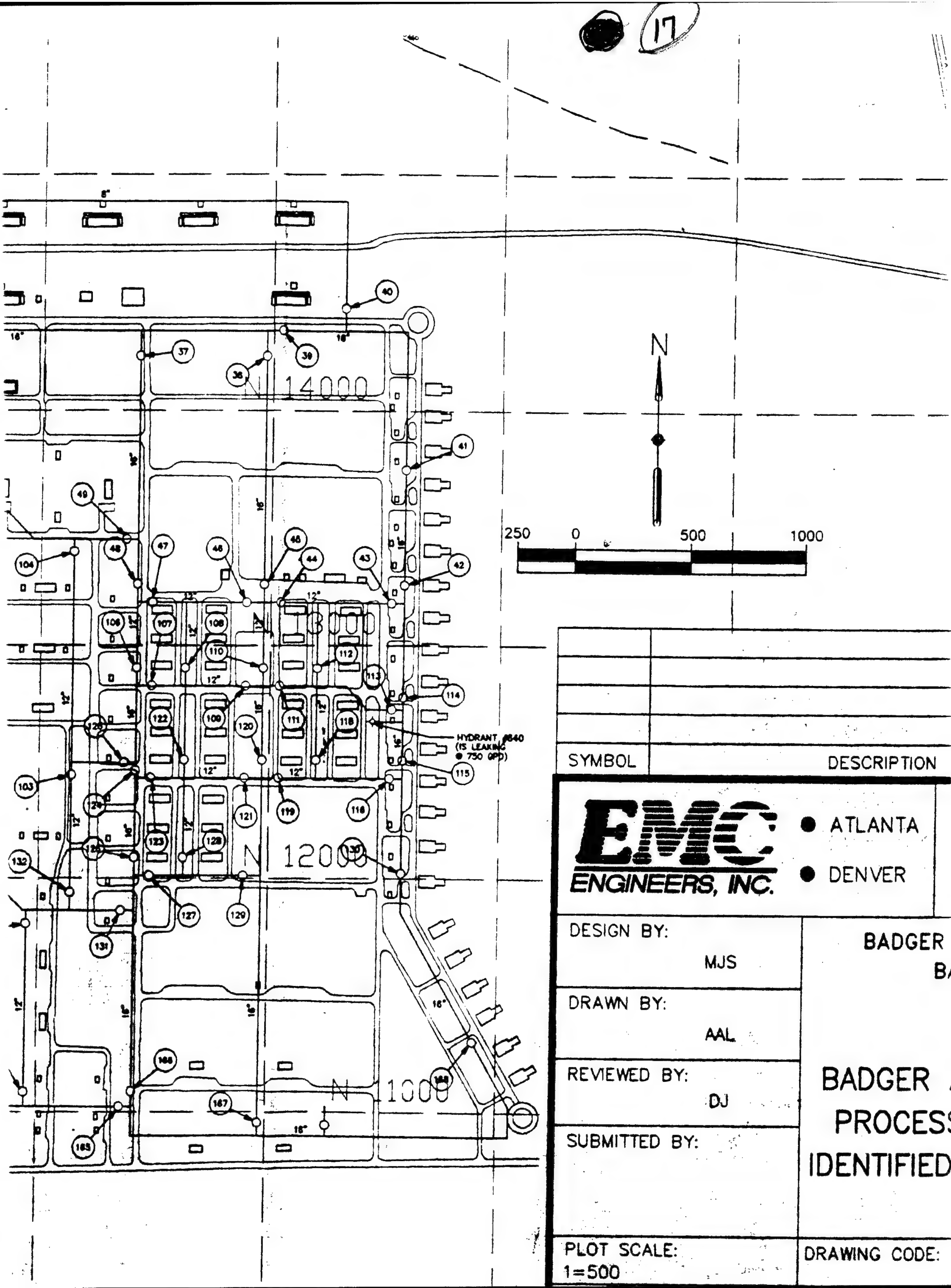
15



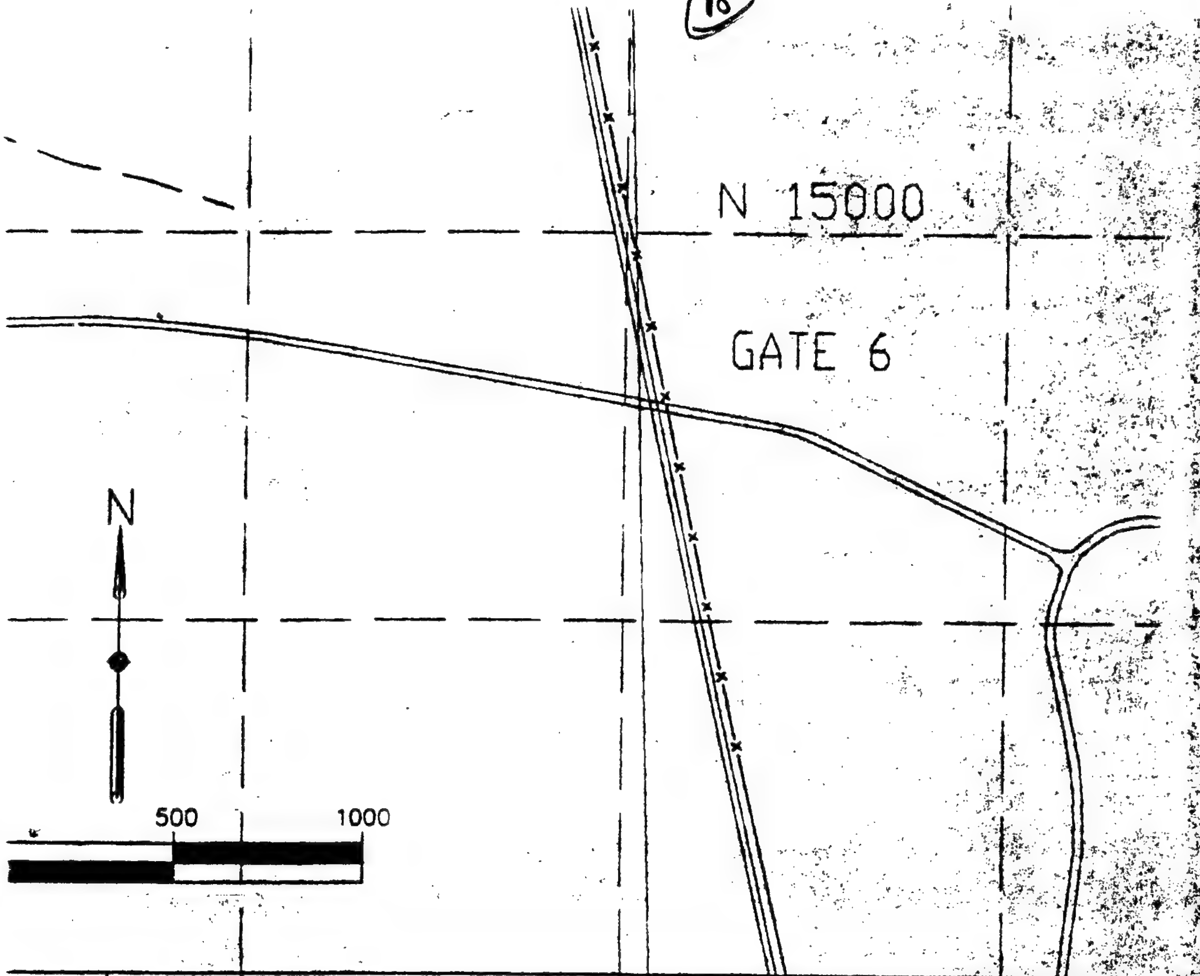
PN NO 2"
HYDRANT #473
(IS LEAKING
● 750 GPD)
HYDRANT #518
(IS LEAKING
● 750 GPD)
HYDRANT #548
(IS LEAKING
● 750 GPD)
HYDRANT #508
(IS LEAKING
● 750 GPD)
HYDRANT #549
(IS LEAKING
● 750 GPD)
HYDRANT #513
(IS LEAKING
● 750 GPD)
HYDRANT #526
(IS LEAKING
● 750 GPD)
HYDRANT #529
(IS LEAKING
● 750 GPD)
24"
16"
12"
10"
8"

16


HYDRANT #475 (IS LEAKING @ 750 GPD)
HYDRANT #573 (IS LEAKING @ 750 GPD)
HYDRANT #564 (IS LEAKING @ 750 GPD)
HYDRANT #567 (IS LEAKING @ 750 GPD)
HYDRANT #577 (IS LEAKING @ 750 GPD)
HYDRANT #555 (IS LEAKING @ 750 GPD)
HYDRANT #551 (IS LEAKING @ 750 GPD)
HYDRANT #592 (IS LEAKING @ 750 GPD)
VALVE 162 IS LEAKING @ 2000 GPD
307


17
N
250
0
500
1000
HYDRANT #840
(IS LEAKING
@ 750 GPD)
SYMBOL
DESCRIPTION
EMC
ENGINEERS, INC.
ATLANTA
DENVER
DESIGN BY:
MJS
DRAWN BY:
AAL
REVIEWED BY:
DJ
SUBMITTED BY:
PLOT SCALE:
1=500
DRAWING CODE:
BADGER
BADGER
PROCESS
IDENTIFIED

18



MBOL	DESCRIPTION	DATE	APPR

EMC
NGINEERS, INC.

- ATLANTA
- DENVER

US Army Corps of Engineers

SIGN BY: MJS

AWN BY: AAL

VIEWED BY: DJ

BMITTED BY:

BADGER ARMY AMMUNITION PLANT
BARABOO, WISCONSIN

BADGER ARMY AMMUNITION SITE
PROCESS WATER SYSTEM MAP
IDENTIFIED LEAKS OCTOBER 1994

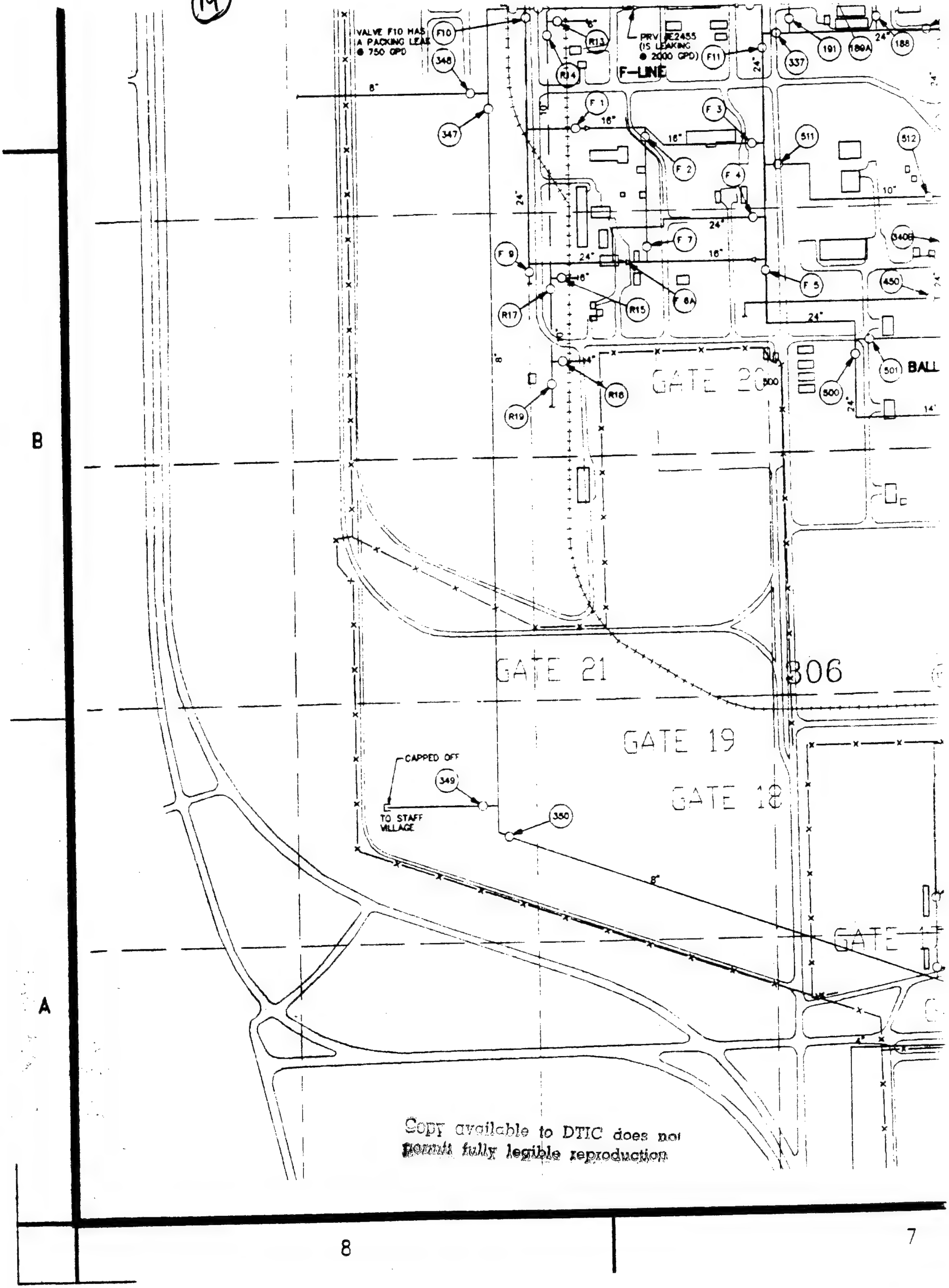
OT SCALE: 500

DRAWING CODE:

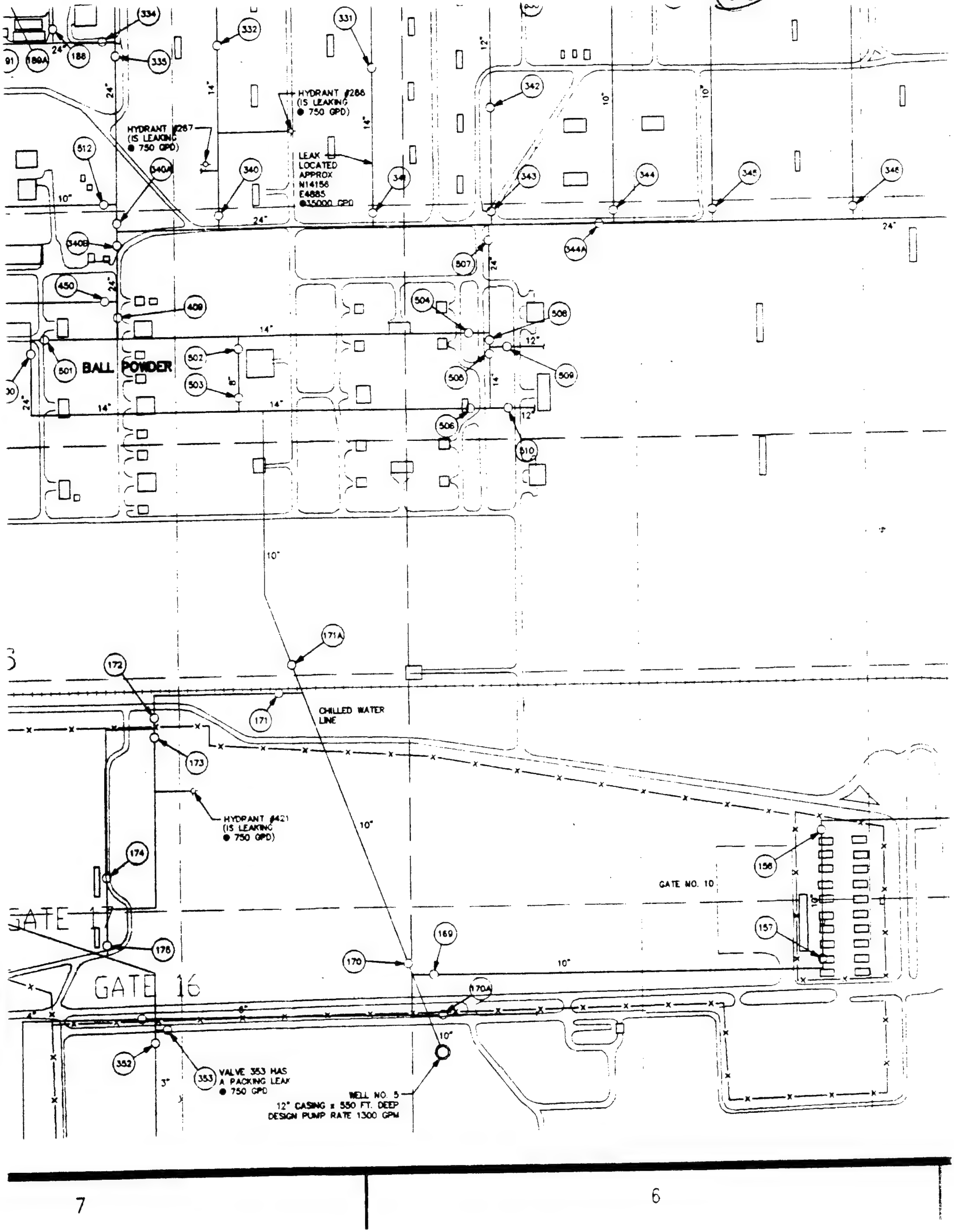
CONTRACT DATE: OCTOBER 1994

SHEET REFERENCE

19

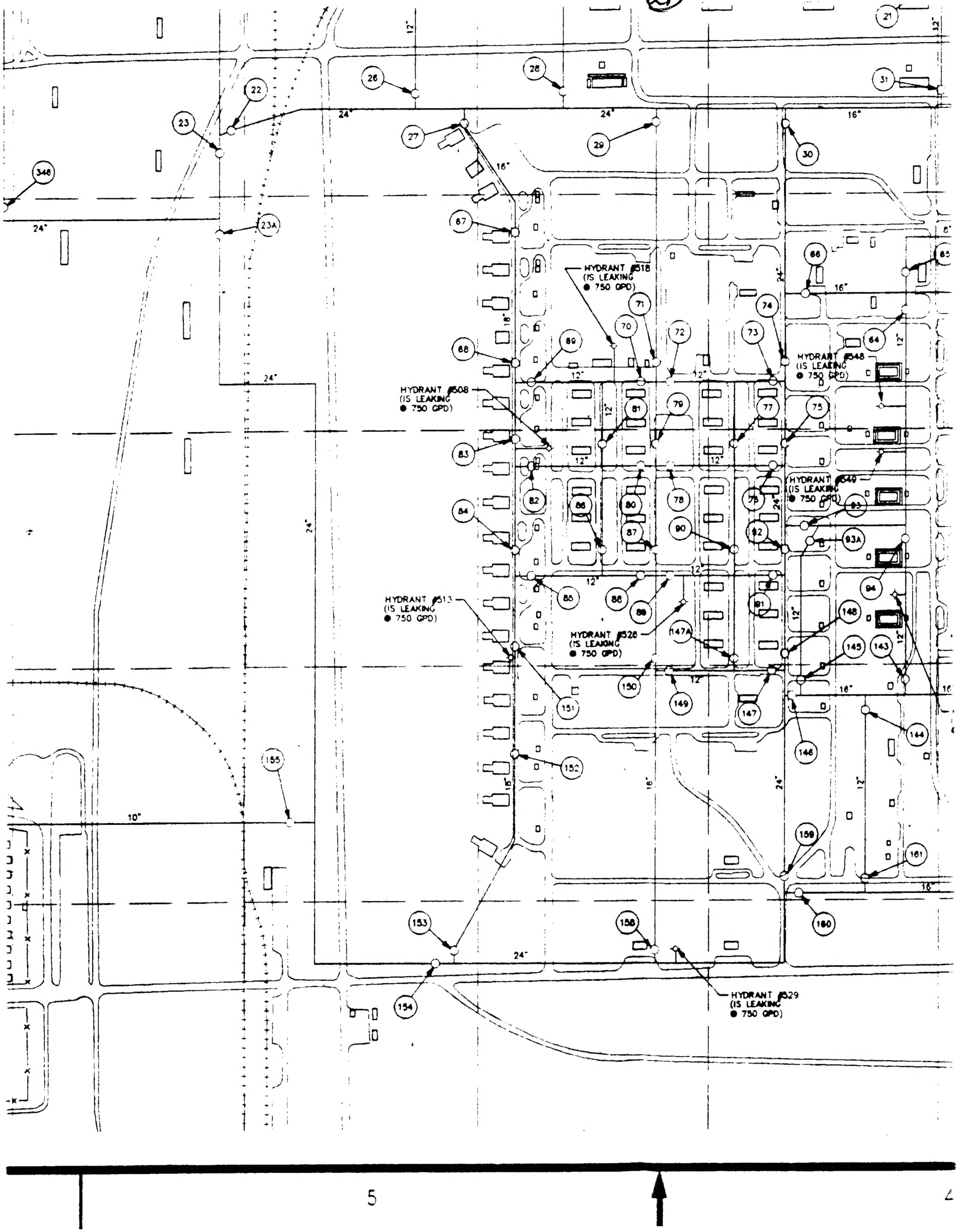


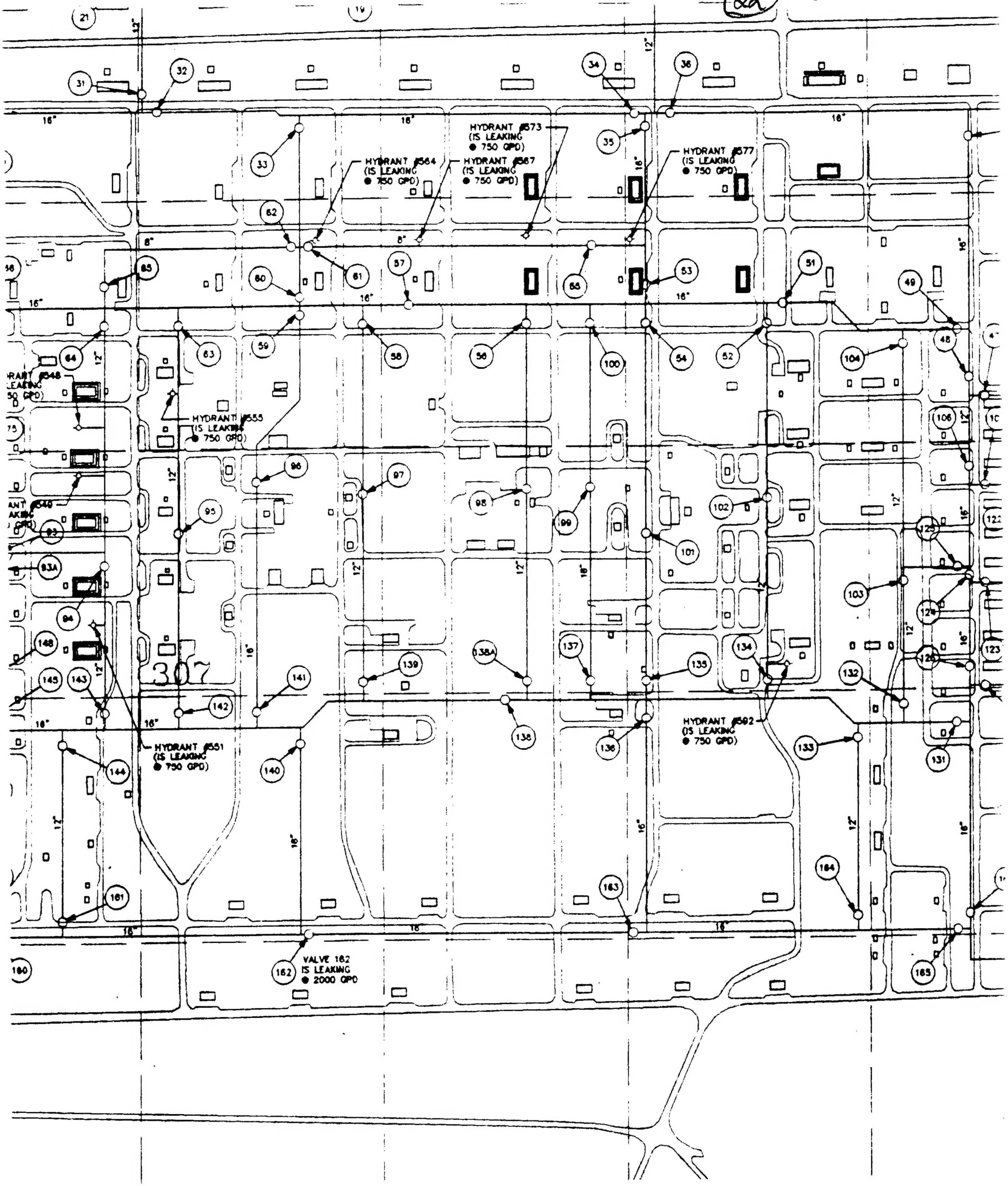
VALVE F10 HAS A PACKING LEAK @ 750 GPD
PRV (IS LEAKING @ 2000 GPD)
F-LINE
GATE 20
GATE 21
GATE 19
GATE 18
306
BALL
CAPPED OFF
TO STAFF VILLAGE
F10
F11
F 1
F 2
F 3
F 4
F 5
F 7
F 8A
F 9
R13
R14
R15
R16
R17
R19
188
189A
191
337
347
348
349
350
450
500
501
511
512
B
A
8
7



HYDRANT #288 (IS LEAKING ● 750 GPD)
HYDRANT #287 (IS LEAKING ● 750 GPD)
LEAK LOCATED APPROX N14156 E4885 ●35000 GPD
BALL POWDER
CHILLED WATER LINE
HYDRANT #421 (IS LEAKING ● 750 GPD)
GATE NO. 10
GATE 17
GATE 16
VALVE 353 HAS A PACKING LEAK ● 750 GPD
WELL NO. 5
12" CASING x 550 FT. DEEP
DESIGN PUMP RATE 1300 GPM
7
6

21

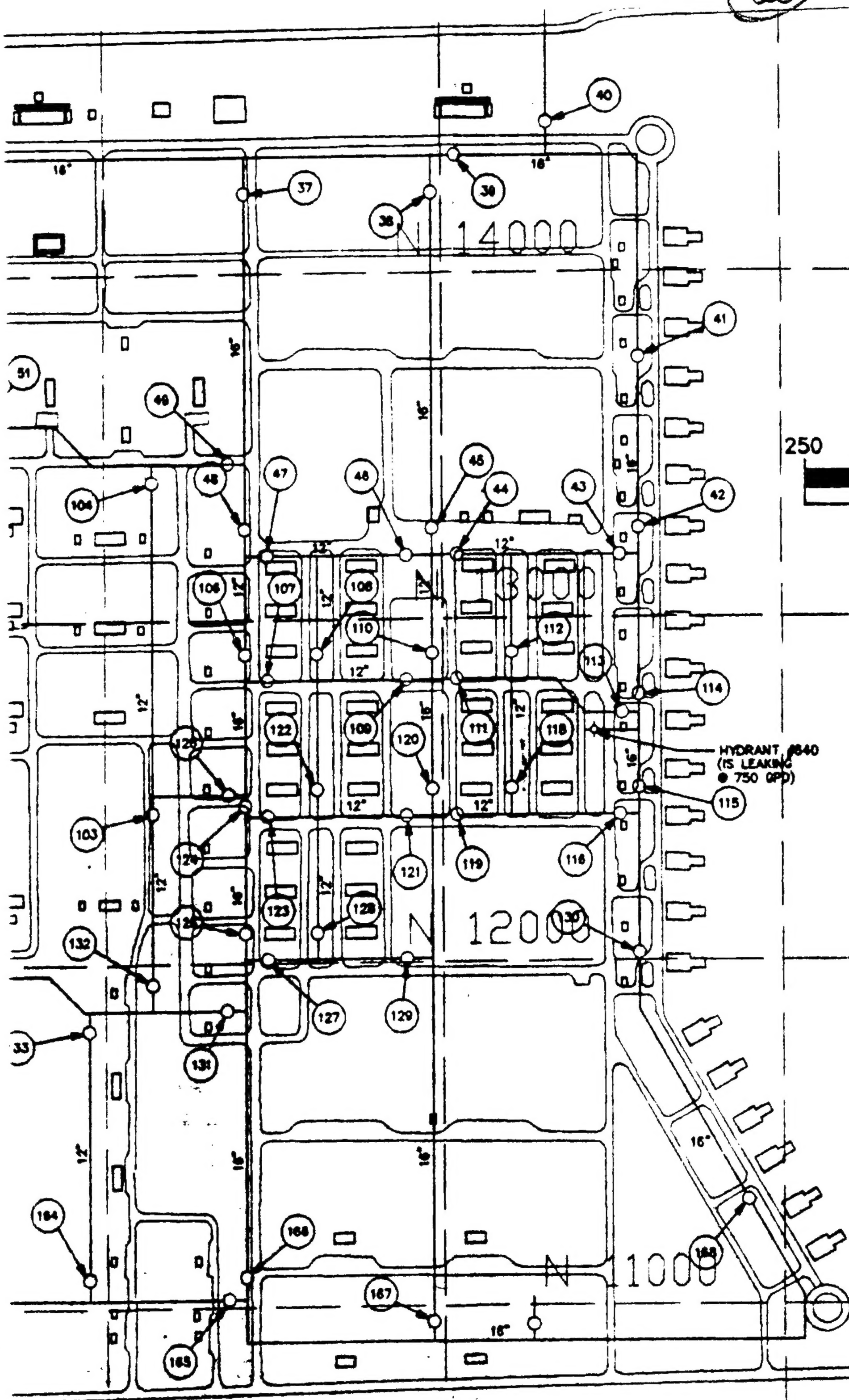

HYDRANT #518 (IS LEAKING ● 750 GPD)
HYDRANT #548 (IS LEAKING ● 750 GPD)
HYDRANT #508 (IS LEAKING ● 750 GPD)
HYDRANT #549 (IS LEAKING ● 750 GPD)
HYDRANT #513 (IS LEAKING ● 750 GPD)
HYDRANT #526 (IS LEAKING ● 750 GPD)
HYDRANT #529 (IS LEAKING ● 750 GPD)
5


HYDRANT #573
(IS LEAKING
● 750 GPD)
HYDRANT #564
(IS LEAKING
● 750 GPD)
HYDRANT #567
(IS LEAKING
● 750 GPD)
HYDRANT #577
(IS LEAKING
● 750 GPD)
HYDRANT #555
(IS LEAKING
● 750 GPD)
HYDRANT #551
(IS LEAKING
● 750 GPD)
HYDRANT #592
(IS LEAKING
● 750 GPD)
VALVE 162
IS LEAKING
● 2000 GPD
307

4

3

(23)

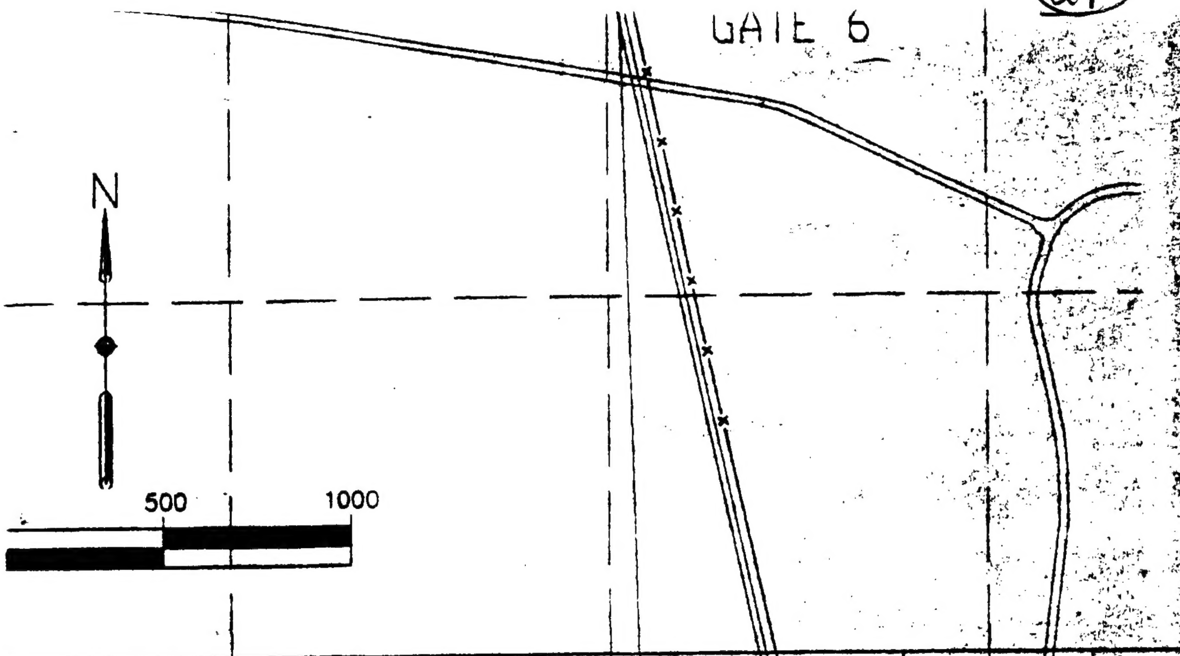


SYMBOL	DESCRIPTIO

EMC ENGINEERS, INC.

- ATLANTA
- DENVER

DESIGN BY: MJS	BADG
DRAWN BY: AAL	
REVIEWED BY: DJ	BADGE PROC IDENTIFI
SUBMITTED BY:	
PLOT SCALE: 1=500	DRAWING CO
DESIGN FILE: V:\1406.004\BGER1	
<Plot Date: 07/24/95>	SHEET 1



MBOL	DESCRIPTION	DATE	APPR

EMC ENGINEERS, INC. ● ATLANTA ● DENVER

US Army Corps of Engineers

SIGN BY: MJS

AWN BY: AAL

VIEWED BY: DJ

BMITTED BY:

BADGER ARMY AMMUNITION PLANT
BARABOO, WISCONSIN

BADGER ARMY AMMUNITION SITE PROCESS WATER SYSTEM MAP IDENTIFIED LEAKS OCTOBER 1994

OT SCALE: 500	DRAWING CODE:	CONTRACT DATE: OCTOBER 1994	SHEET REFERENCE NUMBER 1
SIGN FILE: \1406.004\BGER1		INVITATION NO.	
Plot Date: 07/24/95>	SHEET 1 OF 1	CONTRACT NO.	